AUTOMOBILE ENGINEER

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The Commercial Vehicle Show

OUR heavy vehicle industry continues to expand. This year's Show, the 15th of its kind, was quite definitely the greatest of them all. Export is, of course, the prime objective, the figures in this connection continuing to rise yearly. It is stated that the motor industry as a whole is now furnishing the very handsome figure of 10 per cent. of this country's exports. In order to offer customers maximum carrying capacities, the under-floor engine has made marked headway. This arrangement, in conjunction with the slightly increased dimensions now permitted, should make British vehicles still more attractive to overseas buyers.

Orthodox Engineering

One of the Show aspects that will doubtless strike the visiting engineer is the almost entire absence of unorthodox design features and layouts. To any technician accustomed to visiting similar Shows abroad, the absence of freak designs must be most noticeable. On the whole, this more normal approach to vehicle design, must make for an impression of stability. There have, nevertheless, been very considerable advances in many directions. Among these may be mentioned the increasing use of pilot injection, so that diesel knock is on the way to appreciable reduction. This is probably more important in the case of passenger vehicles now that the power unit is likely to be somewhere beneath the passenger's feet.

Under-floor Engines

There is no doubt that in addition to the question of improved floor space, there is much to be said for the under-floor engine, with its freer accessibility. This factor is probably more of an attraction to operators than the extra two seats gained for passenger accommodation. This accessibility is more marked in some vehicles because of the opportunity given to distribute the accessories along the length of the chassis. It is possible for example, to combine the fan and water pump with the radiator at the front, instal the dynamo and air compressor further along, thus leaving the engine with its injection pump, well away from the rest of the impedimenta. Given a co-operative body design, the injectors can be made generally accessible and the engine removed for overhaul.

The adoption of the newer type of layout brings the customary problems, among them the matter of cooling. In the main this is tackled by the use of more efficient heat transfer units, in conjunction with really efficient fan design and close cowling.

A further point for the under-floor engine is that from the passenger point of view there should be less vibration, since the torque reaction of the engine is in a sense resisted by the vehicle mass as a whole, instead of by one end of it. Another advantage may be a reduction in front axle weight and the size of the front tyres. It is understood that the Sunbeam trolley bus with the motor mounted behind the back axle has resulted in a reduced front axle weight of about 12 cwt.

The Rear Engine

Regarding the rear engine layout as compared with the under-floor scheme, it has to be borne in mind that such a system is really confined to passenger vehicles, and brings with it the old problem of clutch and gear actuation, as well as engine control. This will always present something of a problem in such cases. Further, for a given overall length, the rear engine does take up some useful body space. Even in the case of a coach, where the back seats can be over it, space for a luggage container is lost.

There are more five-speed gearboxes and two-speed axles being employed, but there are no independent suspensions either front or rear, no tubular backbone frames and no hydraulic converters. The Hobbs automatic epicyclic gear may develop into something of use, but it is of course in its early stages at present.

Brake Design

It is noticeable that manufacturers now seem agreed that brake drums have been too big, and are in fact now being improved by being made smaller in diameter and wider. This gives plenty of metal and more space for cooling air between the drum and the wheel.

The growth of weights and operating speeds however has evidenced that in general brakes are still not fully satisfactory, especially overseas. The remarkably low

brake wear figures obtained on trolley buses with rheostatic braking seem to indicate that there is an opportunity for the application of the eddy current brake. It has been said that these brakes in air cooled form and running up to 700 deg. C. are becoming standard practice on Continental buses operating in hilly districts. It is believed that the B.T.H. Company used to make a range of water cooled eddy current brakes.

Apart from such exceptional vehicles as the Thornycroft "Antar" and the Scammell cross-country machine, there was only one example of power steering, namely the Daimler chassis with the Lockheed steering gear.

It would seem that with the easier situation in regard to petrol supplies, the advance of the diesel in the heavy vehicle world is to some degree slowed up. The position to-day is that the petrol engine is probably more than holding its own in this particular field. It is, of course, in any event still the accepted prime mover for small vehicles, and is in fact still largely employed by manufacturers of good size vehicles. Entirely new models have been introduced by two leading manufacturers.

Heavy Fuel Supplies

One factor in this situation is quite evidently the changed situation in the supply of heavy fuel. At one time this was available in unlimited quantities at low prices, but to-day this position is changed. Additionally there is the incidence of taxation, which has considerably raised the cost of diesel fuels. The fuel price differential, therefore, as between the two types of engine, has narrowed and the petrol engine is far from being ousted, even in the heavy vehicle field.

As previously mentioned, much has been done to improve the combustion process in the diesel engine and the delayed injection principle has taken out a good deal of diesel knock. There is one other point, and that is that when diesel engined vehicles go abroad the matter of fuel cleanliness presents something of a problem. Filtration becomes of extreme importance and users overseas undoubtedly find difficulty in keeping their vehicles supplied with fuel sufficiently clean and free from water to furnish reliable operation. Petrol, on the other hand, appears to be much cleaner by contrast, and operators are able to rely on more reliable service on this account.

The general layout of engines for heavy vehicles does not change radically, though many detail improvements are, of course, made. Efforts have been made to secure better and more even cooling for operation overseas, directional cooling in one form or another is found in conjunction with separate ports designed to provide more satisfactory dissipation of heat, particularly around the exhaust valves. Another matter in which improvement has been made, is in the securing of better torque curves, particularly in the lower and medium speed ranges. While b.h.p. ratings have in the past been regarded as all important, yet for commercial vehicle service the flatness of the torque curve is undoubtedly a very advantageous characteristic.

In conformity with the general practice in vehicles towards well tried reliable design and general layout, clutches have, if anything, become still more standardised. The single dry disc, generally Borg and Beck, is the most widely used component. Certain firms continue to design and make their own units, but in the main the proprietary component is the most commonly employed.

Automatic Transmissions

There has not been much headway in the use of the torque converter, though certain firms in the United States of America continue to employ it with satisfaction. One interesting scheme is that sponsored by the Self-Changing Gear Company, which consists of a Wilson gearbox, the clutch and brake bands being pneumatically actuated by electrically operated valves through relays. This arrangement provides fully automatic action, with driver control if desired.

There are some new five-speed gearboxes shown, and there is a range of auxiliary gearboxes made by M. O. Harper, Ltd., one of which has the power take-off for front wheel drive. Although the use of the two-speed axle is in some cases deferring the use of a five-speed box, there are several examples of this axle being employed with a five-speed box. In general, the heavy vehicle maker has preferred to keep the gearbox as simple and sturdy as possible, and synchromesh has been slow in making its way into this field. It does, however, appear to be gaining some ground, and on the new 7-ton Bedford chassis it is employed on three of the four speeds. There are still very many new boxes with internal tooth dog clutches without synchromesh.

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Under Floor Engines

WITHOUT doubt the most important development at this year's Commercial Vehicle Show has been the increasing adoption of the under-floor location for the power unit. Whereas two years ago only two engine builders showed designs suitable for under-floor installation, this year six, out of the total of thirteen British engine manufacturers exhibiting, offered one or more models of this type. The basic requirements for such installation are low overall height and good accessibility of the accessories and various points requiring routine attention, and some interesting variations are to be found in the means adopted to solve the problems raised. It is however of interest to note that all without exception have adopted the layout with the cylinders extending to the off-side of the vehicle.

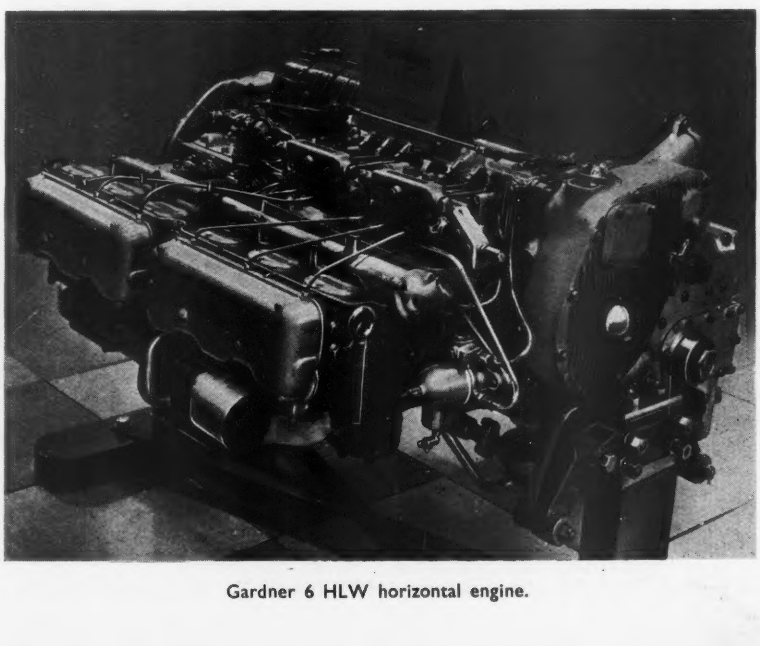
The greater rigidity that can be obtained from the use of a monobloc cylinder and crankcase construction is of advantage when considering the suspension of an under-floor unit, and is generally favoured. Minor modifications have been found necessary in the lubricating system particularly regarding the return of used oil to the sump. In the Leyland 0.600 horizontal engine the cylinders are inclined slightly upwards at about 3° from the true horizontal to facilitate oil drainage from the valve rocker gear back to the sump. With the arrangement of cylinders at the off-side of the vehicle drainage will be further assisted by the camber of the road in this country, but obviously the reverse effect will occur in some circumstances. Lubrication of the A.E.C. under-floor engine is on the dry sump principle employing separate scavenge and pressure pumps. Some variations are to be seen in the shape of oil sump adopted, ranging from the shallow form located beneath the crankcase on the Sentinel engine, giving nevertheless a capacity of some six gallons, to the "slipper" type projecting sideways from the crankcase cover and carrying an extended filler pipe accessible from the nearside of the vehicle, as on the Leyland and Gardner engines.

Accessory drives present a problem on the under-floor engine if the overall height is to be kept to a minimum, more particularly where the engine is installed with the cylinder block extending beyond the side members of the frame. Where, as on the installation of the horizontal Gardner 6 H.L.W. engine, the bulk of the engine lies within the frame, the problem is not so acute and it has been possible to preserve the normal location for the fuel injection pumps, fuel lift pump etc. This arrangement does, of course, entail the provision of access doors in the floor of the vehicle for maintenance purposes.

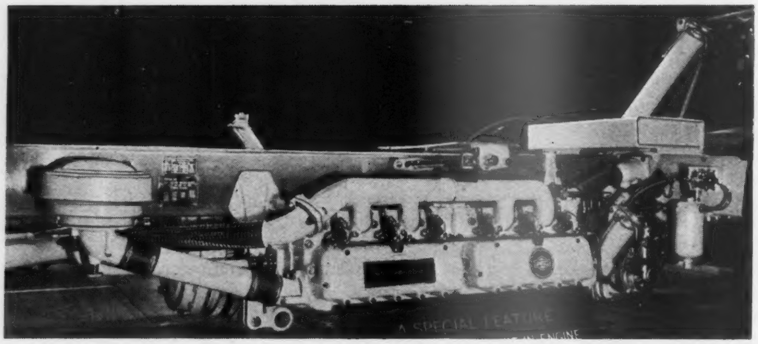
An arrangement has been adopted on the new Dennis "Dominant" single decker chassis which results in a particularly clean engine layout. This engine, developed from the Dennis 0.6 vertical model of 105 mm. bore and 146 mm. stroke, is available either in naturally aspirated or supercharged form giving from a capacity of 7.6 litres, an output of 100 B.H.P. or 130 B.H.P. respectively at the governed speed of 1800 r.p.m. The timing train at the flywheel end has been simplified and drives directly the high level camshaft from the end of which is also driven the injection pump, inclined slightly outwards to give good accessibility. The brake compressor or exhauster is mounted at the forward or free end of the camshaft.

At the front end of the crankshaft a supplementary gear case provides the drive for the fan, dynamo, and Roots type blower of the supercharged version of the engine. The water circulating pump has been removed from the engine and combined with the fan in the separate radiator unit. On the Sentinel and A.E.C. engines the fuel injection pumps are positioned transversely ahead of the cylinder block and driven through bevel gearing from the half-speed camshaft drive. In this position, the pumps are somewhat vulnerable to dust and splash thrown up by the front wheels and on the Sentinal chassis a baffle has been provided to shield the pump.

A different approach is made on the Leyland engine where a gear on the forward end of the crankshaft drives through an idler gear a half speed shaft carried in a casing extended from the side of the crankcase cover. The injection pump, driven from the rear of the shaft, is carried on a cradle close to the crankcase cover and parallel to the engine axis while the exhauster extends from the forward end. A further variation is to be found on the Meadows 6 DC 630 engine in its



Gardner 6 HLW horizontal engine.



Underfloor installation of A.E.C. 9.6 litre engine.

horizontal form, resembling in some ways the Leyland arrangement but utilising a flange mounting for the injection pump, thus eliminating the separate cradle and avoiding an exposed pump coupling. Considerable variation is also to be found in the manifold arrangements adopted on the flat engines. Both manifolds above the head (Leyland), both below (Gardner), exhaust above (A.E.C.) and exhaust underneath (Dennis) are each favoured by the various manufacturers.

Removal and replacement of the 9.6 litre and 11.3 litre under-floor A.E.C. engines is greatly facilitated by the provision of a special lifting device consisting of a chain and roller hoist built permanently into the vehicle. The hoist is screw operated by means of the normal vehicle wheelbrace and by its use it is stated that, employing two mechanics only, the complete engine can be removed in 13 minutes and replaced in 24 minutes. Although not provided with permanent jacking gear on the vehicle, the under-floor Leyland 0.600 engine can be removed, replaced and started up within 50 minutes.

There is no doubt that most of the under-floor engine designs exhibited are basically adaptations of existing vertical models which, in view of the rapid and as yet not wholly proved demand, indicates a justifiably cautious approach. When the success of the under-floor installation has been completely established, the question of designing basically new power units essentially for under-floor installation will no doubt be explored.

That the under-floor engine is not the only answer to the demand for increased floor space is shown by the two Foden rear engine chassis, one equipped with the Gardner 6 L.W. engine, the other employing the Foden 6 cyl. 2 stroke engine. Engine accessibility in this arrangement would seem to be an improvement over that of the under-floor layout and most existing vertical engines would lend themselves to such an installation with very little modification.

Engine Performance

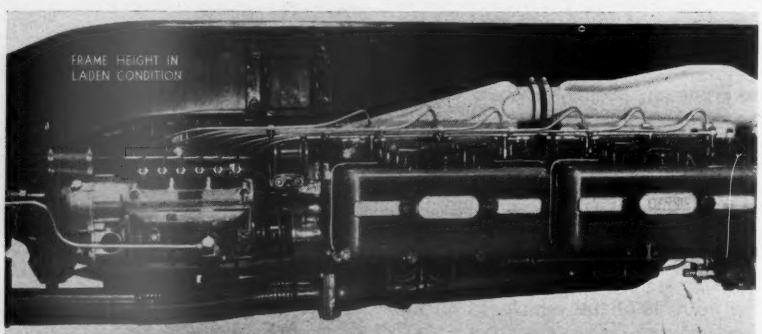
There is evidently a continuation of the trend, noticeable two years ago, towards increased power for the heavier class of vehicle. A.E.C. have added to the existing range of 7.7 litre and 9.6 litre engines a six cylinder model of 11.3 litres. This is basically the same as the 9.6 litre engine, differing only in bore, which has been increased from 120 mm. to 130 mm., and inlet valve size and other minor details. The output is increased by 20 per cent. to 150 B.H.P. at the maximum governed speed of 1800 r.p.m., the maximum torque at 1100 r.p.m. being 505 lb. ft. This engine is made both in vertical and horizontal form, the main constructional difference being that whereas the vertical has a detachable cylinder block, the horizontal version employs monobloc construction.

Increased ratings have now been adopted for the L.W. series of Gardner engines, including the new 6 H.L.W. horizontal model, and the 8.6 litre Crossley engine. An increase in power of 10 per cent. from 102 B.H.P. to 112 B.H.P. has been made possible for the 6 cylinder Gardner models by improvements to engine breathing and modifications to the fuel injection equipment. To deal with the higher thermal stresses pistons of Lo. Ex. 8, a heat treated aluminium alloy, are fitted.

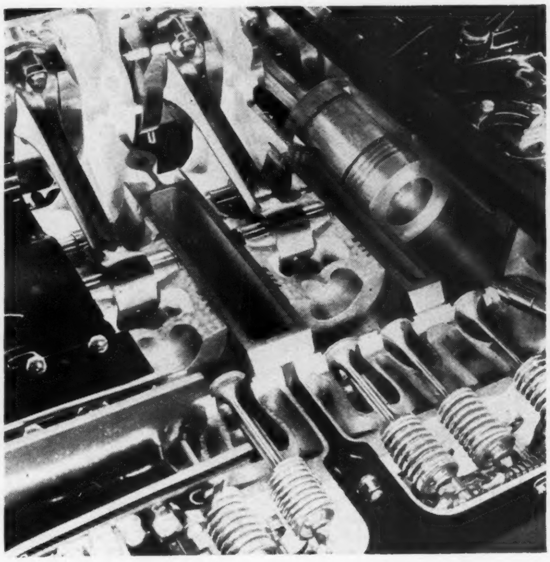
A substantial improvement has also been made in the power output of the 8.6 litre direct injection Crossley engine largely by attention to the design of the inlet passages and manifold which are now situated on the opposite side of the cylinder to the exhaust manifold. In addition to reducing air inlet temperature and thus promoting a denser air change, inlet resistance has been reduced by the adoption of downdraught ports, the net effect being to raise the power from 100 B.H.P. to 114 B.H.P. at 1750 r.p.m.

Supercharging as a means of increasing the power of an existing design has been adopted by Dennis on their under-floor engined "Dominant" chassis. A Roots type blower driven from a supplementary gear case at the front of the engine delivers air at a pressure of 6 lb/sq. inch, raising the maximum output from 100 B.H.P. at 1800 r.p.m. for the normally aspirated engine to 130 B.H.P. at the same speed. A further example of supercharging is to be seen on the Meadows 6 DC970 engine, a six cylinder design of 15.9 litres capacity which is now available with Brown Boveri turbo blower mounted at the rear end of the cylinder block. At 1650 r.p.m. the output of this engine is 270 B.H.P.

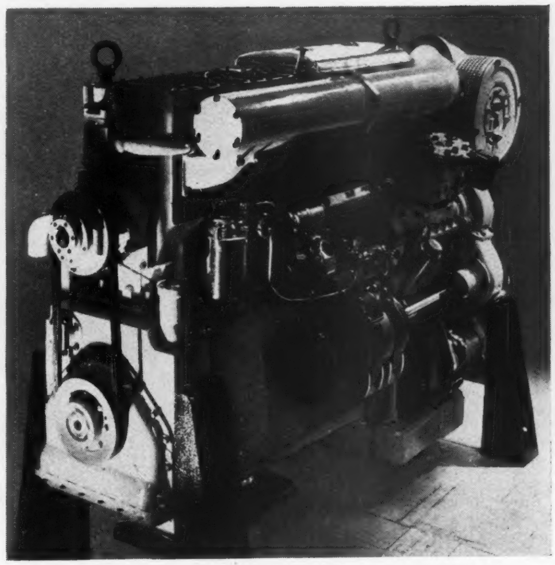
This engine makes an interesting comparison with the very light and compact Rover "Meteorite" V-8 engine, fitted in the Thornycroft Mighty Antar tractor, and in which aircraft practice has been extensively employed. Crankcase, cylinder blocks and cylinder heads are all cast in DTD.133 aluminium alloy, the chrome manganese wet-type steel liners being chromium plated at the top end only. The Ricardo Comet Mk. III combustion chamber is employed.



Arrangement of fuel pump drive on Dennis engine.



Part view of A.E.C. sectioned engine exhibit.



Meadows 15.9 litre turbo-charged engine.

With a dry weight of only 1500 lb. and rated moderately at 250 B.H.P. at 2000 r.p.m. for vehicle installation, this engine has the remarkable power/weight ratio of 6 lb. per H.P., less than half the average figure for the conventional transport engine. At its full rating of 320 B.H.P. at the unusually high speed for so large an engine of 2400 r.p.m., this ratio attains the quite exceptional figure of under 5 lb. per h.p.

For engines of such large power there would appear to be obvious advantages in the use of larger numbers of cylinders than the customary six. With the greater freedom available in the under-floor installation engines with eight and even twelve cylinders may not be uncommon in the future.

The general increase in the size of the power unit now fitted to the heavier class of passenger and goods vehicles has been accompanied by a demand for smaller units of from 70 to 80 B.H.P. for use in medium weight vehicles. Within this category are the familiar Perkins P6 of 4.73 litres capacity giving a normal output of 70 B.H.P. at 2200 r.p.m. and the Albion four cylinder engine of 4.8 litres rated at 75 B.H.P. at a speed of 2000 r.p.m. Models of similar capacity are also produced by Leyland, Dennis and Thornycroft, all rated at 75 horsepower.

A newcomer to this range is the Meadows 4DC330, a four cylinder design of 120 mm. bore and 120 mm. stroke rated at an output of 80 B.H.P. at 2200 r.p.m. This is of the direct injection type with toroidal cavity pistons and embodies several features of interest. A departure has been made from conventional British practice in the adoption of flange mounting for the injection pump, an arrangement that makes for neatness in the layout. A flywheel is mounted on the free end of the pump shaft to damp the reaction from the cams, and the governor, a variable speed mechanical unit, is vertically mounted on the timing case. A removable cover on the side of the case gives access for fuel pump timing. As on the larger Meadows engines a centrifugal advance and retard mechanism is incorporated in the fuel pump drive, a feature to be found on only one other make of engine, the Albion 4.8 litre four cylinder.

The Morris Commercial direct injection oil engine first shown two years ago now has the cylinder bore increased from 85 mm. to 87 mm. which with a stroke of 125 mm. now gives it a capacity of 4.46 litres. The rated output is 70 B.H.P. at 2400 r.p.m. This engine retains the special annular orifice injector which, in conjunction with a deeply re-entrant piston cavity, provides efficient combustion without the necessity for rotational air swirl.

At the lower end of the scale the four cylinder Perkins P4 unit of 46 B.H.P. at 2200 r.p.m. and the Thornycroft TR6/D1, a six cylinder unit of 54 B.H.P., provide economical power units for vehicles in the 3 ton class. The Thornycroft is the smallest direct injection engine in regular production for vehicle use.

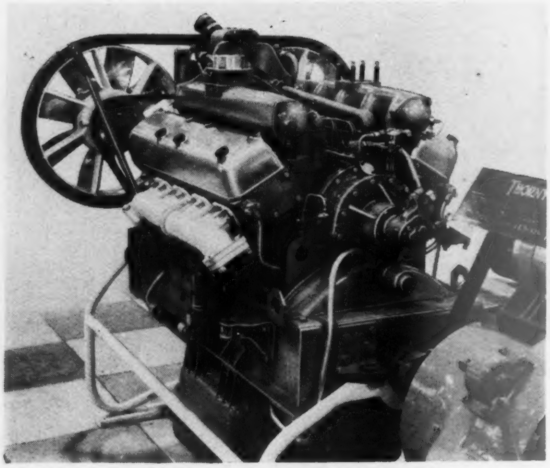
Smoother Engines

Engine performance having now reached a level where major improvements can no longer be expected, attention has been directly recently towards the reduction of noise and vibration, previously accepted as concomitants inseparable from the compression ignition cycle.

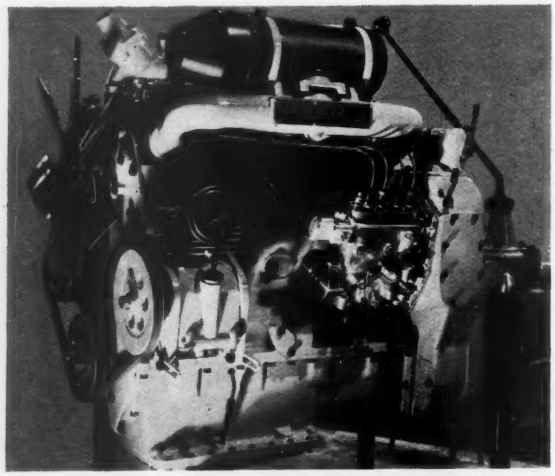
An outstanding contribution in this direction is the system of pilot injection now manufactured by C.A.V. and fitted to several of the A.E.C. 9.6 litre engines in the Show. It has long been known that the familiar "diesel knock" arises principally from the uncontrolled combustion of fuel injected during the delay period. This is, of course, the period elapsing between the commencement of injection and the point when combustion of the fuel actually begins. By means of a two-stage lift camshaft in the fuel injection pump and an injector of special construction, the quantity of fuel delivered during the early part of the injection is reduced. Once combustion has begun, the rate of fuel delivery is increased to the normal value for optimum efficiency.

The improvement effected by this system is particularly noticeable at idling and on pulling away under load from a low speed, two conditions where the oil engine has compared most unfavourably with the petrol.

The Leyland 0.600 and 0.300 series of engines are now fitted with the Leyland "Aphonic" injector which, as its name implies, aims similarly at the elimination of combustion noise. By the use of a high ratio of valve guide to seat diameter it has been possible to reduce considerably the opening pressure without any accompanying reduction in the closing pressure such as would give rise to early carboning



Rover Meteorite V-8 engine as fitted in Thornycroft "Mighty Antar" tractor.



New Meadows 4 DC 330 engine with flange-mounted injection pump and harmonic balancer.

of the injector. A similar feature has been incorporated in the injectors fitted to the latest series of Gardner L.W. engines.

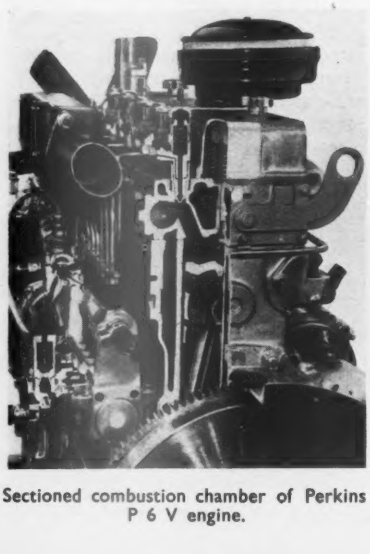
One obvious consequence of the suppression of combustion noise has been to throw into prominence mechanical noises from the engine not previously regarded as important. There can be little doubt that greater effort will now be made for mechanical quietness.

The inherently better balance of the six cylinder engine has led to a preponderance of this type over the four cylinder. For engines in the 5-6 litre class however, there is much to be said for the four cylinder type, particularly where direct injection is employed, in its avoidance of small cylinders. Further, the manufacturing cost should be lower. A very complete answer to the problem of vibration is to be found in the new Meadows 4 DC330 engine. This incorporates a harmonic balancing gear to eliminate secondary out of balance forces. Situated in the crankcase below the crankshaft and parallel to it, a pair of contra rotating shafts are driven at twice engine speed through an idler gear from the rear end of the crankshaft. These terminate at a point near the centre main bearing and carry balance weights.

To ensure quietness and freedom from vibration it is now rare to find anything but flexible engine mountings employed. These may take the form of cushioned suspensions by means of rubber pads taking the weight of the engine in compression and absorbing movement in shear. Increasing use is also made of link suspensions as a convenient way of ensuring accurate location of the engine while providing for movement of the engine about its neutral axis A combination of rubber and link suspension is used on the horizontal Leyland engine in the Royal Tiger chassis supported at the rear by links with Harrisflex bushes and at the front on a rubber bonded bush. A vertical tie rod at the rear limits movement due to torque reaction. The Albion 4.8 litre 4 cylinder engine of the Victor FT39 chassis retains the patented Albion system of bellcranks restrained by springs and rubber pads at the rear combined with inclined rubber pads for the front end.

Reducing Wear

With very few exceptions, all the diesel engines to be seen at this year's Show have either been in production for several years or have been developed from models, or along lines, with which the manufacturers have previously gained extensive experience. There is in consequence nothing of a novel or experimental nature about them and detail design has been directed more towards reducing wear and facilitating replacement of worn surfaces.



Sectioned combustion chamber of Perkins P 6 V engine.

The use of renewable cylinder liners would now appear to be universal, the pre-finished push-fit dry liner, usually of centrifugally cast iron, being most widely favoured. This not only makes for easier servicing but enables materials or treatments to be used which would not be practicable for the complete cylinder.

Dry liners are usually flanged at the top and clamped between the cylinder head gasket and block. This procedure is reversed on the A.E.C. 7.7 litre vertical engines, the flange being near the lower end and clamped between the top of the crankcase and the underside of the detachable cylinder block.

Several examples of wet liner are however to be found, particularly in the smaller size of engine. Normally when wet type liners are used, they are flanged at the top and clamped between the head and cylinder block, a shoulder near the lower end forming a water seal on a compressible joint ring. Owing to the extreme thinness of section of the liners on the Rover "Meteorite" engine, distortion has been avoided by the use of a separate junk ring between the base of the cylinder block and the crankcase.

In the Morris Commercial 4.46 litre engine the arrangement is unusual in that no water seal is formed between the liner and the top of the block, the cylinder head seating simultaneously on the end of the liner and the top face of the cylinder block. Variations in the length of the liners are corrected by shims placed under the lower seating flanges.

To reduce cylinder bore wear, increasing use is now being made of chrome plating for the rubbing face of piston rings. Usually confined to the top ring only, the treatment is now applied to the first two rings of the Gardner LW engines. Chromium plating of the cylinder bores, on the other hand, does not appear to have gained in favour, the only examples of this being the Sentinel engine and Rover "Meteorite", both of the indirect injection, Ricardo air swirl chamber design.

Increasing use is made of replaceable valve seat inserts and the stelliting of valve faces provides valves that operate over long periods before attention becomes necessary. Chromium plating of the valve stems, as on the Leyland engines, also has a beneficial effect in reducing wear and helping to maintain concentricity of the valve in its seating.

Opinion continues to be divided as to the relative merits of soft or hardened crankshafts, Gardner and Albion among others, adhere to the use of unhardened shafts with white metal lined bearings, while Tocco hardening and nitriding are employed by others in conjunction with lead bronze or copper-lead bearings. These would appear to be necessitated if overall length of the engine is to be kept down to the minimum.

An important factor in the reduction of wear is the rigidity of the crankcase and its ability to maintain correct alignment of the bearings. Most manufacturers now favour the one piece cylinder block and crankcase. Usually in cast iron, an exception is the Morris Commercial engine which employs aluminium alloy, and also the Foden 2 stroke engine.

Two part construction is however retained in the LW range of Gardner engines, in which the crankcase is made in light alloy, heavily ribbed for stiffness and extending well beyond the crankshaft centre line. A similar construction is employed on the 8.6 litre Crossley engine. Detachable cylinder blocks are also used on the vertical models of the A.E.C. range of engines, the crankcase being in alloy cast iron. Piston design appears to have undergone few changes. Aluminium alloy pistons are now general on 4 stroke engines and usually carry three compression rings and an oil control ring above the gudgeon pin and an oil scraper below. The pistons of the Rover Meteorite engine are unusual in the ratio of diameter to skirt length, which following aircraft practice is almost 1 to 1 compared with the more usual ratios of 1.3-1.5 to 1. The piston in the Foden 2-stroke engine on the other hand, owing to the requirement of covering the air inlet ports at the top of the stroke, has a ratio of approximately 1.8 to 1. This piston, contrary to usual four stroke practice is of cast iron, tinplated, and carries an exceptionally wide stepped ring completely surrounding the top land of the piston. A full description of this most interesting engine was given in the Automobile Engineer for April 1949.

Overseas experience has emphasised the importance of efficient filtration of both air and lubricant. Large size air filters, usually of the oil bath type, are now fitted to most export models and their use has extended in the home market. On under-floor installations the necessity for adequate air filtration is even more obvious and a good example is that on the supercharged Dennis engine. Having a very large annular entry, the filter on this engine helps to keep air velocities low.

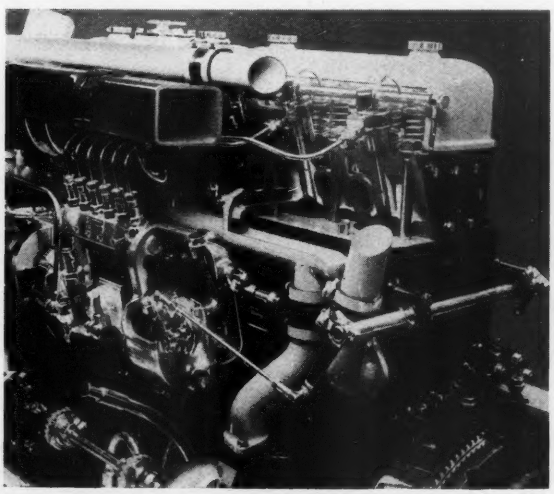
On the other hand, particularly for some operating areas, an air intake at a somewhat higher level on the vehicle would be a better arrangement. It may also be noted that despite the provision of filters for the air intake, there are still some unprotected crankcase vents. Being usually oily, they must tend to attract dust which may find its way into the engine. The necessity for adequate filtration of the lubricant is well recognised and full flow filters are in some cases supplemented by magnetic filters.

Cooling Arrangements

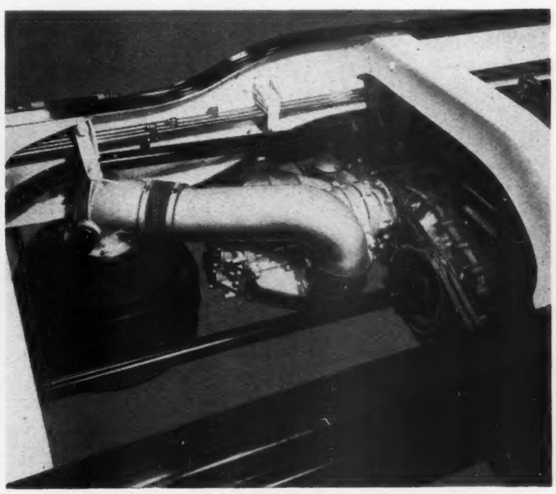
The cooling arrangements employed in conjunction with the various underfloor installations are of interest. The position most favoured for the radiator, namely beneath the vehicle floor, not only places a limitation on frontal area but the front axle, etc. obstruct the free passage of air through the radiator. This problem has in general been solved by the use of large multi-bladed fans, close cowled for maximum efficiency, mounted directly in the radiator casing and driven by cardan shaft from the front end of the engine.

On the Dennis "Dominant" chassis, fitted with the horizontal 7.6 litre engine, the cooling arrangements consist of a very compact unit mounted just behind the front axle below frame level. This comprises a contra flow radiator behind which is mounted an 8-bladed axial flow fan running in a close fitting cowl. The inclusion also in this assembly of the water circulating pump and thermostat results in a self-contained cooling unit of ample capacity with a frontal area of only 2.8 sq. feet.

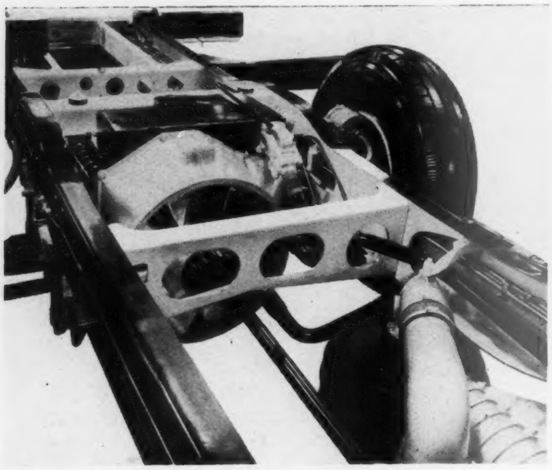
To improve still further the effi-



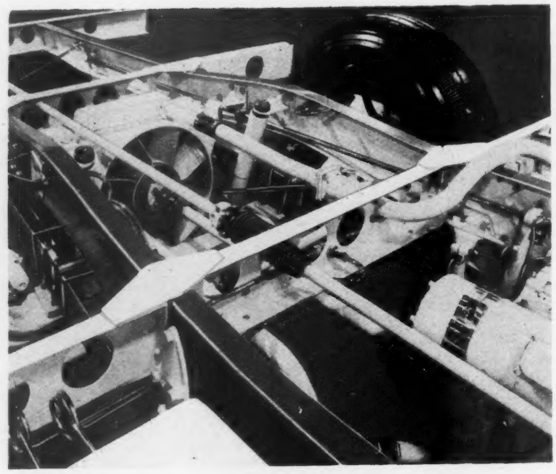
Part sectioned Thornycroft CR 6 engine.



Air cleaner on Dennis "Dominant" chassis.



Cooling unit on Dennis "Dominant" chassis.



Radiator and fan assembly on Crossley chassis.

ciency of the fan and prevent excessive air swirl, fixed vanes are incorporated in the close fitting shroud surrounding the 8-bladed fan of the cooling unit on the A.E.C. Regal Mk. IV chassis, fitted with the A.E.C. 9.6 litre underfloor engine. This unit incorporates 7 Still tubes and the whole assembly is flexibly mounted in the chassis. A separate header tank is mounted on the offside of the chassis frame between the cooler and the engine and carries the filter.

The new Foden chassis, although having the engine situated at the rear, has certain cooling problems in common with the under-floor arrangement in that the normal position of radiator at the front of the vehicle is impracticable. Mounted at the side of the vehicle, the radiator is entirely dependant on the efficiency of the fan to ensure an adequate flow of air. The fan, having six blades of 21 ins. diameter and fully shrouded, is driven through a friction coupling and helical gears from the transmission side of the engine clutch. This arrangement has been found to have the additional advantage of serving as an effective clutch brake during gear changing. In the Foden two-stroke application an oil cooling radiator, consisting of twelve horizontally disposed tubes, is provided on the outside of the main radiator so that the cooling air passes first over these tubes. A small header tank mounted on the top of the radiator ensures that the free water surface is at all times above the level of the cylinder water jackets for all normal attitudes of the vehicle.

PETROL ENGINES

Improvement in Detail Design

ONCE again it is evident that the petrol engine for commercial vehicles is far from obsolete. This year's Exhibition proves that it is still supreme in the small vehicle class, and that it is still employed by manufacturers of quite reasonable sized goods vehicles. Two leading manufacturers have, in fact, introduced entirely new models. Some time back there was a period when petrol engines were in almost universal use, yet there was an abundant supply of comparatively unwanted heavy fuel at much lower prices. To use this, the compression ignition engine was developed. The pendulum has, however, been swinging slowly back for some time, "Diesel fuels" as they are commonly called having become dearer and carrying heavier tax burdens. To-day the turbine engine is making deep inroads into the supplies of the heavy and paraffin type fuels, and it may well be that in the not too far distant future petrol may be the fuel most readily available.

Another point is that of cleanliness. Adequate filtration is imperative for the successful use of diesel fuels. Overseas operators report that whereas diesel fuels contain an unwarrantable proportion of water, petrol is reasonably clean. It is not without significance in this connection, that whereas Meadows, for example, have largely been concentrating on compression ignition engines, they have taken steps to make available a petrol edition of each of their engines.

Basic design does not vary much, except as to whether the valves shall be overhead or at the side. Regarding valves, however, there is a praiseworthy tendency to separate the ports and give the coolant a better chance of more rapidly dissipating the heat from the neighbourhood of the exhaust valves. Directional cooling in one form or another is being generally adopted, and there is a marked tendency to return to the use of torsional vibration dampers at the front end of the crankshaft.

An interesting method of achieving this is found on the Commer 'Avenger' chassis, in that to the forward extremity of the crankshaft pulley, from which water pump and dynamo drives are taken, is bolted a rubber disc. From this the six-bladed 19in. fan is driven by a shaft, thus providing the dual effect of relieving the fan from acceleration stresses due to sudden changes of speed and, to some degree, functioning as a torsional vibration damper.

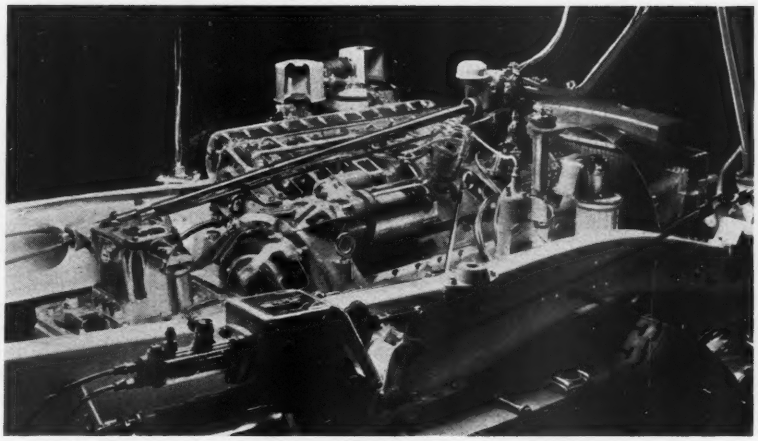
Another point is the effort made to obtain the flattest possible torque curve in the lower and medium speed ranges. Over-much regard has for too long been paid to b.h.p. ratings. For commercial vehicle service the height and flatness of the torque curve is of far greater importance. It becomes increasingly difficult to reconcile engine dimensions with their ultimate output and in some cases the multiplicity of variations appears to be without reason.

The Dodge range is a clear example.

A six-cylinder side valve petrol engine of $3\frac{7}{16}$in. bore by $4\frac{1}{2}$in. stroke, used in a 6-ton chassis, has a volumetric capacity of 250.6 cu. in., yields a maximum output of 114 b.h.p. and 204lb. ft. torque. A similar engine of the same bore has the stroke shortened by $\frac{1}{4}$in., reducing the capacity by 14 cu. in. and the torque by 12lb. ft., a different insignificant in an engine of that size. This is installed in a 2/3 ton chassis.

Next down the scale, the one-ton chassis has an engine of $3\frac{1}{4}$in. bore by $4\frac{3}{8}$in. stroke, yielding 102 b.h.p., while at the bottom of the range apparently the same engine has the stroke shortened by $\frac{1}{4}$in. to yield 96 b.h.p. All these powers are at 3,600 r.p.m., the torque figures being at 1,200 r.p.m., so the four engines have a total capacity variation of but 33 cu. in. in volume, 18 b.h.p. and 32 lb. ft. torque. On the face of it there would appear a strong case for simplifying the manufacturing and spares position by cutting the types of engine from four to two at least.

It is interesting to compare the engines in the Morris Commercial range. There is a new six-cylinder O.H.V. engine of 88 mm. bore by 115 mm. stroke, which yields 100 b.h.p. at 3,260 r.p.m. This particular engine is fitted to a 5-ton chassis for heavy overseas duties. The same engine is used on a 2/3 ton chassis for lighter duty and is arranged to yield 70 b.h.p. at 3,000 r.p.m., the lower output being procured by the simple expedient of fitting a 32 mm. bore carburettor instead of one of 40 mm. as fitted to the higher output engine.

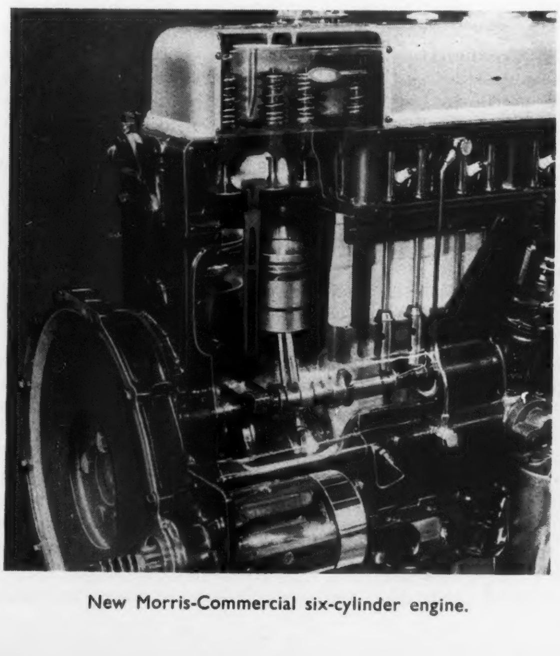


Sectioned Commer "Avenger" engine.

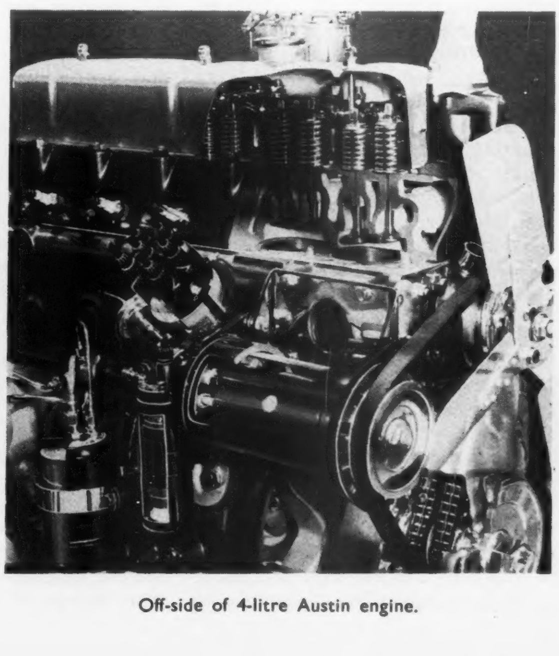
A four cylinder side valve engine is fitted to both 5-ton and 2/3 ton ranges. Dimensions are 100 mm. bore by 120 mm. stroke, swept volume being 3,770 c.c. Compression ratio is 6.1 : 1. With a 35 mm. carburettor as fitted to the 5-tonner, it yields 80 b.h.p. at 3,000 r.p.m. and 175 lb. ft. torque at 1,500 r.p.m. The engine in the 2-ton range has a 32 mm. carburettor and develops 70 b.h.p. at 3,000 r.p.m. and 165 lb. ft. torque at 1,500 r.p.m.

There is then the four-cylinder O.H.V. engine of 80 mm. bore by 102 mm. stroke which yields 42 b.h.p. at 3,250 r.p.m. and 91.6 lb. ft. torque at 1,500 r.p.m. The smallest in the range is the four-cylinder side valve 73.5 mm. by 87 mm. engine, developing 36 b.h.p. at 3,500 r.p.m. and 67 lb. ft. torque of 2,000 r.p.m. Incidentally this engine is shared by the Morris Cowley van and the Morris Oxford car.

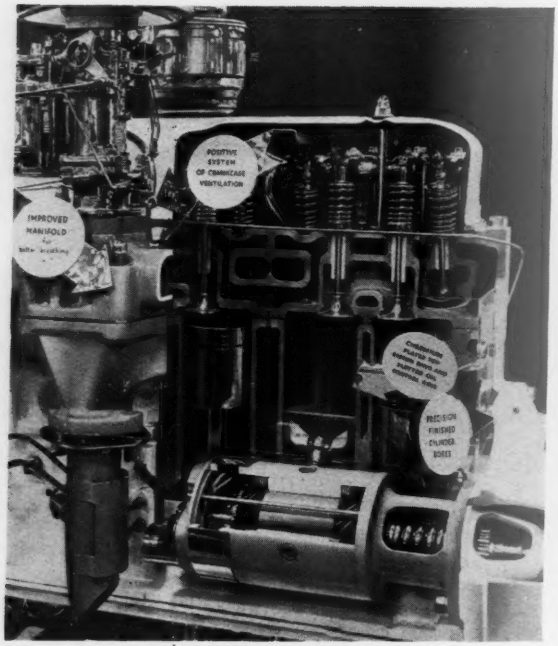
The new six-cylinder Morris Commercial engine is of interesting yet straightforward design. It has a rigid cast alloy iron block incorporating the crankcase. Full length water jacketing gives more than usual water space and access is arranged to permit the removal of sludge or scale. The overhead valves are mounted in the cylinder head, which is, of course, detachable. A generously proportioned heat-treated alloy steel crankshaft has $2\frac{5}{8}$in. diameter journals, the crankpins being $2\frac{5}{16}$in. diameter. All bearings are of thin wall white metal-lined type. Alloy steel valves work in detachable cast iron guides, the exhaust valves only having renewable seats. Aluminium alloy pistons carrying two compression and two oil control rings are fitted



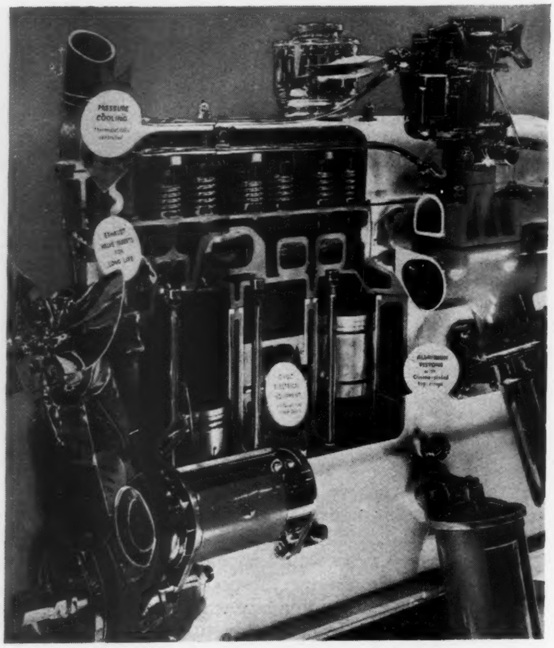
New Morris-Commercial six-cylinder engine.



Off-side of 4-litre Austin engine.



Valve arrangement of Bedford "Extra Duty" type engine.



Valve arrangement of new Bedford "S" type engine.

with large diameter gudgeon pins, to which the connecting rod small ends are clamped.

A gear type oil pump, driven from the crankshaft, draws oil from the sump through a floating type oil strainer and supplies the main oil gallery on the off-side of the engine through a renewable external cartridge-type filter. Oil is fed direct to both crankshaft and camshaft bearings. Coil ignition is used, the distributor being driven in tandem with the oil pump from the camshaft by helical gearing. The engine is flexibly mounted at four points.

Another new engine appears in the new Bedford S type chassis. This $3\frac{7}{8}$in. $\times$ $4\frac{1}{4}$in. six-cylinder engine has a capacity of 300 cu. in., developing 110 b.h.p. at 3,000 r.p.m., and no less than 234 lb. ft. torque at about 1,200 r.p.m. It has a noteworthy flat torque characteristic in that 220 lb. ft. is available at all speeds between 1,200 and 1,800 r.p.m. One new feature is the use of full length dry cylinder liners fitted to slip limits. The liners are located by a flange at the upper rim. Another feature is the method of securing the cylinder head. The fourteen high tensile steel studs are screwed into reinforced anchorages in the upper flanged portion of the crankcase, and pass freely through the water spaces in the cylinder block. The load is thereby removed from the top of the cylinders and more evenly distributed throughout the casting.

A robust, counterweighed seven-bearing crankshaft has all journals and crankpins "Tocco" hardened. All bearings are now of copper-lead alloy and are thin wall. Crankshaft thrust is taken by white metal thrust washers fitted to either side of the centre main bearing. A torsional vibration damper is built into the crankshaft pulley.

Tin-plated aluminium alloy pistons are fitted, with three pressure rings above the gudgeon, one other being at the bottom of the oval ground skirt. The top ring is taper faced and chromium plated, the second one being stepped and the remaining two are both grooved and slotted. Fully floating case-hardened steel gudgeon pins, bored for lightness, are positively located by circlips. Each connecting rod cap is secured in position by double-waisted bolts as in aircraft practice. A single tab strip is used to lock the nuts.

In contradiction to the earlier "Extra Duty" engines which have the exhaust valves at an angle, all valves on the new engine are mounted vertically and at the same level. Silchrome 'XB' exhaust valves seat in renewable inserts of specially hard "durachrome" white high chromium iron. Controlled crankcase ventilation is a new feature. Air is drawn through an oil bath air-cleaner fitted in the rocker cover. A spring loaded valve regulates the depression in the crankcase so that at all speeds a stream of clean air is passing through it. The carburettor air intake has its separate oil bath air cleaner. Helical gearing is employed for the camshaft drive, the crankshaft gear being of mild steel and the camshaft gear being of aluminium alloy.

Special attention has been given to the new pressure cooling system, the operating pressure ranging between $3\frac{1}{4}$ and $4\frac{1}{4}$ lb. per sq. in. in order to raise the boiling point of the coolant to 221/244 deg. F. This, in conjunction with a lubricating oil capacity of 20 pints, has proved effective in maintaining working temperatures at reasonable figures, even under tropical operating conditions.

A new approach has been made to the old problem of facilitating engine removal. Front bumper, radiator grille and radiator are readily detachable, after which the engine may be supported on a special trolley, the front frame cross member may be removed, and, after disconnection, the engine may be wheeled out on the trolley.

Vulcan exhibited a large articulated furniture pantechnicon, the tractor unit being fitted with a $4\frac{1}{2}$-litre four cylinder 102 by 140 mm. bore and stroke engine. Output is 78 b.h.p. at 2,800 r.p.m., maximum torque being 210 lb. ft. at 1,000 r.p.m., which suggests good pulling power at slow speeds. This engine has a cylinder block detachable from the crankcase and all dimensions are on the generous size.

Commer and Karrier share a new four-cylinder side-valve engine of 81 mm. bore (3.19in.) by 110 mm. stroke (4.33in.), having a piston displacement of 2,226 c.c. As fitted to the Commer, a downdraught carburettor is employed and it yields

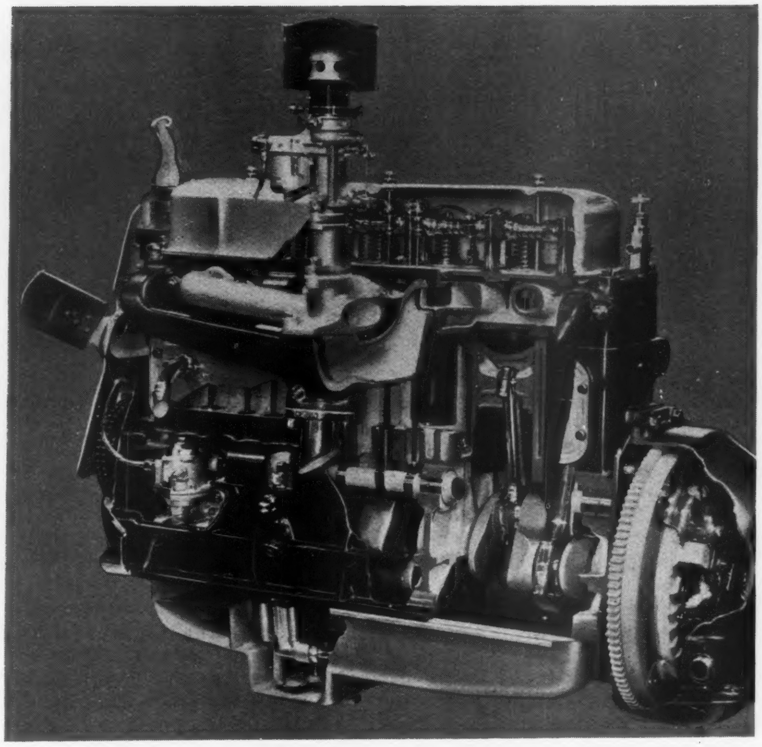
50 b.h.p. at 3,200 r.p.m. and 104 lb. ft. torque at 1,700 r.p.m., whereas on the Karrier Bantam the carburettor is of up-draught and the advertised rating is 48 b.h.p. Cylinder bores are chromium plated by the Listard process under Van der Horst patents, which process has given such excellent results on other Commer vehicles. Cylinder block and crankcase are formed in one casting of exceptional length and rigidity. The cylinder head is detachable. It is worthy of note that light weight cast iron pistons are employed. Bearings are of the pre-finished white metal type.

Full pressure lubrication is used and new features are an external A.C. by-pass filter and a floating pick-up in the sump. Provision has been made for an oil spray to the bores from the cheeks of the connecting rods. This new engine is being used as a replacement to all the older four-cylinder 14 h.p. engines.

As exhibited, the Thornycroft "Sturdy Star" for gross laden weights of 8¼ tons, is fitted with a compression ignition engine, but it is also available with a four-cylinder side valve petrol engine of 3⅞in. (98.4 mm.) bore by 5in. (127 mm.) stroke, having a swept volume of 235.8 cu. in. (3.865 litres). Compression ratio is 5.6 : 1, maximum brake horse power 68 at 2,600 r.p.m. and maximum torque being 163 lb. ft. at 1,500 r.p.m. Touching the question of torque, 145 lb. ft. is obtained at all speeds between 800 and 2,400.

The engine is of straightforward conventional Thornycroft design, cylinder block and crankcase being in one and the head being detachable. Renewable dry liners are fitted and the pistons are aluminium alloy. The mounting of this engine is by two pairs of rubber mountings, one pair being in front of the timing case, the other at the back of the gearbox. The mountings are on a line passing through the centre of gravity of the unit, and torque reaction is taken by pre-loaded rubber bushings on each side of the power unit, their mounting being on a transverse line again passing through the centre of gravity of the unit.

To conform with common Fire Brigade practice, Dennis fit a 100 mm. by 120 mm. four-cylinder O.H.V. petrol engine to the new small F.8 fire engine. The unit, which develops 80 b.h.p. at 3,000 r.p.m. and 168 lb. ft. torque at 1,750 r.p.m., is so arranged that, like the same Company's 5-litre diesel engine, the cylinder block is reversible for right or left hand operation, Crankshaft journals are 2⅜in. dia. and are carried in three white metalled shell bearings. The connecting rods are directly metalled.



Near-side of 4-litre Austin engine.

The camshaft is driven by silent gears disposed at the back of the engine. Lubrication is by a fully submerged Eaton oil pump and a full flow filter is fitted outside the engine. Total oil capacity is 23 pints. Manifolds on this engine are reversible to accommodate up-draught or down-draught carburettors at will.

On the Guy "Vixen", the original engine is retained. This four-cylinder O.H.V. petrol engine of 95 mm. bore by 130 mm. stroke, which is fitted in a 4-ton capacity chassis, develops 165 lb. ft. torque at 1,400 r.p.m. This is fitted with an up-draught carburettor.

Meadows show only one petrol engine, it being the petrol version of the 6D6 630 C.I. engine, with which it is closely comparable up to the point of the cylinder head, which on the petrol version is an aluminium alloy casting. Its output is 117 b.h.p. at 2,400 r.p.m. and maximum torque is 174 lb. ft. at 1,300 r.p.m. The comparison with the C.I. engine is that the latter develops 130 b.h.p. at 1,900 r.p.m., and 113 lb. ft. torque at 900 r.p.m.

A new development by Wellworthy is the use on heavy duty pistons of a bonded insert piston ring carrier. The aim is to obtain maximum heat transference, which is impaired when carriers were used without some such form of bond. The ring carriers are of austenitic iron, which has a closely similar coefficient of expansion to that of the aluminium alloy used in the piston itself.

The method of manufacture is interesting, the ring carrier being precoated with an alloy of suitable chemical composition, and the resultant coated carrier is then placed in the piston mould while still hot, the casting of the piston itself immediately following. Not only is it claimed that heat transference does not suffer in any way, but the bond will transmit a reasonable amount of stress.

The development of flexible engine mountings continues on well established lines. Metalastik offer a range designed to carry loads up to 1½ tons per unit. Naturally rubber sections are pre-loaded. Metalastik also offer a torsional vibration damper. It comprises a stamping to be fitted to the outer side of a crankshaft belt pulley. To this is directly bonded an "L" shaped rubber section and to that, in turn, is bonded a steel ring.

Silentbloc show for the first time the "Frustacon" mounting. It incorporates an unusually large volume of rubber which works in both shear and compression. The compression pad, which is at the top and the rebound section at the bottom, are moulded in one piece in the form of a bobbin which is directly bonded externally to it to carry the mounting bolt.

CARBURATION AND INDUCTION

Increasing Attention Paid to Economy

THE increased cost of motor spirit has doubtless concentrated attention upon carburation generally. It is to be expected that still further work will be done on carburation and induction design, in order to secure maximum miles per gallon. In this connection it is interesting to note that in the two years since the last Commercial Motor Show, little progress has been made towards petrol injection, as a substitute for the conventional carburettor. All petrol engined vehicles exhibited are fitted with an ordinary carburettor. Since the downdraught type of carburettor was introduced in the 1930's it has grown widely popular, and far more engines will be observed equipped with a downdraught carburettor than any other type. While the downdraught installation has some technical advantage in the matter of being able to use a slightly larger choke or venturi than the vertical or horizontal instrument, its greatest advantage is probably in its accessibility. With the carburettor mounted on top of the induction manifold, it is much easier to get at for service and adjustment. In some instances, however, chiefly where bonnet space and other considerations are important, vertical or horizontal carburettors are employed.

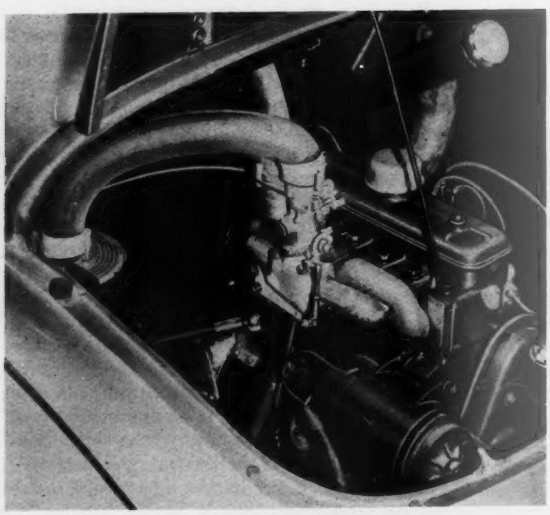
In the commercial vehicle field, the open-choke type of carburettor, represented in this country by Zenith, the Zenith-Stromberg and the Solex, is the most widely used. Some installations, however, incorporate the S.U. constant-vacuum instrument, among which are some Morris vehicles. Carburettor production has become a highly specialised industry, and the process of zinc-base die-casting has facilitated quantity production to precision standards of complicated castings, having intricate cored passages. While most of the smaller sizes of open-choke carburettor are designed on "static" lines, having no metering parts in the metering system, a number of the larger types include an economiser device, which provides a lean mixture for economical cruising.

This is usually effected either by bringing into action an extra fuel jet as full throttle is approached, or by introducing more air into the emulsion system at part-open throttle. The small valves within the carburettor which provide this alteration in mixture strength may be operated either by pressure across the carburettor or by mechanical interconnection from the throttle spindle. With economiser systems there is also the accelerating pump, and this small component is now a common feature on the larger models of open-choke carburettor. It consists of a small syringe, which injects a small and metered quantity of fuel into the air stream when the throttle is opened. The Solex carburettor incorporates a diaphragm type of pump operated by induction depression, while Zenith and Zenith-Stromberg use a brass piston pump linked to the throttle spindle by mechanical linkage.

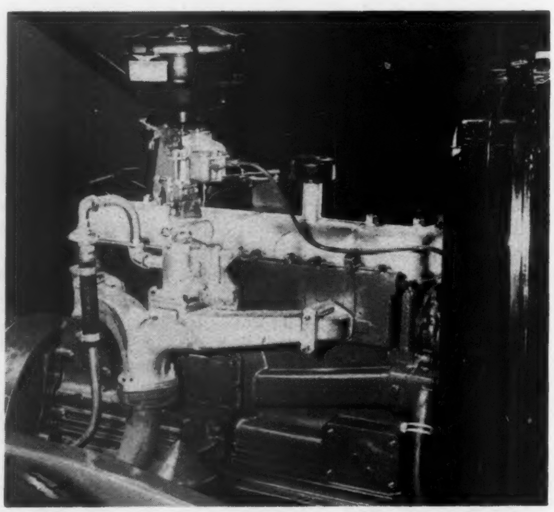
Carburation of American vehicle exhibitors is by the Carter and Ball and Ball downdraught carburettors. These incorporate vacuum operated economy devices with piston type accelerating pumps mechanically operated.

Provision for starting from cold on the open-choke types is either by strangler valve with interconnected fast idle, or by a small auxiliary starting carburettor. Most of the Solex models exhibited are equipped with the auxiliary device known as the Solex Starting Carburettor. This consists of a small metering system entirely independent of the main carburettor, which supplies small quantities of fuel and air in sufficiently rich proportions to provide an immediate start in cold weather. It is controlled by the rotation of a disc valve, connected to a knob on the dash, which puts the device in or out of action.

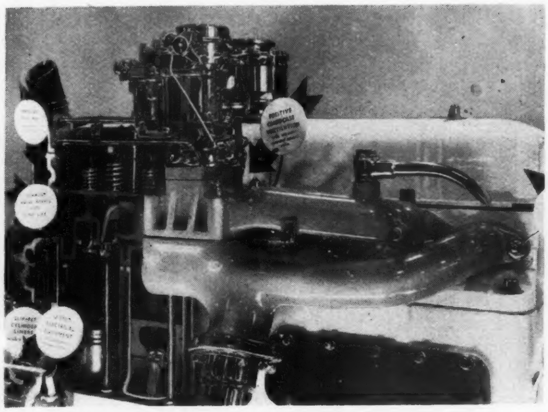
The Zenith-Stromberg instruments incorporate an off-set strangler valve with interconnected fast idle linkage, so that when the strangler valve is closed for starting, the throttle valve is opened a small but predetermined amount. Cold starting on the S.U. constant vacuum carburettor is effected by lowering the sleeve carrying the actual metering jet orifice, in which fits the metering pin attached to the piston. The lowering of the sleeve enlarges the metering annulus around the needle, when in the lowest position, and so provides the rich mixture necessary for cold starting. So far as



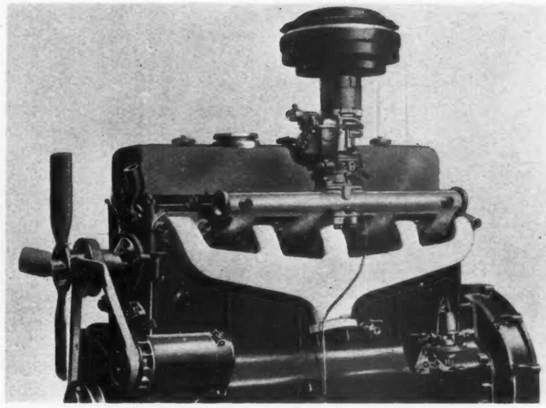
Thermostatically-controlled hot-spot on Renault van.



Induction and exhaust system on Reo "Gold Comet".



New Bedford 4-litre induction manifold and downdraught carburettor.



Four port, straight rake induction manifold on $4\frac{1}{2}$-litre Morris Commercial.

the American carburettors are concerned, the strangler valve with linked fast idle is universal. A number of Solex carburettors incorporate an automatic speed governor within the carburettor itself.

The most common fuel system is to have the petrol tank at any convenient point in the chassis, and from the tank the fuel is supplied to the carburettor by means of a pump, which is generally of the mechanically operated diaphragm pattern. The most popular pump of this type is the A.C. In most installations the pump is attached to the side of the crankcase, and the operating lever of the pump bears against a special cam on the engine camshaft. In the A.C. design the cam action charges the pump on its suction stroke, while the actual delivery stroke is obtained by a spring working against the other side of the diaphragm.

The S.U. fuel pump, also of the diaphragm type, is electrically operated. In some instances the Autovac system is still employed. This device consists of a small cylindrical tank mounted usually on the engine bulkhead, a foot or more above the carburettor. By an ingenious system of an inner tank and valves, fuel is drawn by engine suction up into the small inner tank, from which it runs into the larger outer one, thus providing a gravity feed to the carburettor. Some twenty years ago this system was very popular on private motor cars also, but has, of course, been superseded by the introduction of the mechanical and electric fuel pumps.

Air Silencers

Air silencers, attached to the air entry of the carburettor, are used in some instances, but a number of installations dispense with a silencer and fit a cowl over the air intake. For export conditions some vehicle manufacturers specify an oil-bath air cleaner. This may be placed in series with the air silencer, or in some cases the silencer and cleaner elements are included in a single unit casing.

The general tendency is still to arrange the induction and exhaust manifolds on the same side of the engine, with a hot-spot between the two below the "T" junction of the riser and the main induction tract gallery. Hot-spot schemes vary a good deal, but the one that seems to find most favour among engine designers is the "contact" hot-spot, where the two manifolds are bolted together by a flange on each casting. Usually the area inside the exhaust manifold flange is left open, so that the exhaust gases play directly upon the floor, in a downdraught installation, of the induction tract. Some manufacturers, notably Commer and Austin, go further and leave an opening in the flange of the induction manifold also, interposing a thin copper plate between the two castings. Since there is only the thickness of this plate, usually of the order of $\frac{1}{16}$in. between the exhaust gases and that of the incoming mixture, its response to the heat of the exhaust is extremely rapid, and further, it has little mass to retain unwanted heat.

The more complicated thermostatically controlled hot-spot, employed on many American engines, has so far made little progress in this country, probably on account of its increased cost. It has, however, been a feature of the Vauxhall and Bedford products for a number of years, and is exhibited on the 12 h.p. Bedford P.V.C. van. It is also employed on the two versions of the Studebaker engine. In cases where the induction and exhaust manifolds are on opposite sides of the engine, it is common practice to employ hot coolant water to a jacket cast round all or part of the induction manifold. Among examples of this form of induction heating are the Land Rover and the Daimler Ambulance.

Two-cylinder Induction Systems

An interesting example of unconventional design is that of the Trojan engine. Operating on the two-stroke principle, the four water-cooled working cylinders on one side of the vee have common combustion spaces to each pair, and are fed under a slight positive pressure from the two air-cooled charging cylinders through automatic valves. Mixture is supplied by a single horizontal Zenith V type carburettor, and after passing into the charging cylinders through the automatic valves, is fed into the working cylinder on the inside of the vee. The exhaust port is situated at the bottom of the stroke on the outside working cylinders, and the exhaust gases pass into an expansion box placed as close as possible to the working cylinder block. From there the gases flow into an exhaust silencer of the acoustic pattern, and thence to the tail pipe. An air silencer of Trojan design is now fitted to an elbow piece connected to the carburettor.

A popular and well-tried normal twin-cylinder installation is that which powers the Bradford van. This is a version of the Jowett opposed twin power unit and is similar in layout to the engine employed in the Jowett car. As the cylinders are horizontally opposed to one another, the induction system takes the form of a long almost horizontal casting turning downwards into the vertical at each end, where the flanges are formed for attachment to the two cylinder heads. The casting consists of two separate tracts of round section side by side in the horizontal plane, one behind the other. One, the front tract, is the induction tract

proper, fed in the centre by a downdraught Zenith carburettor. The rear tract is in circulation with the coolant system, and in fact provides the outlet of hot water from the cylinder heads to the radiator header tank.

This second tract is, of course, included to heat the induction system over its considerable length and so assist evaporation of the fuel content of the mixture. At a point slightly to the left of the carburettor, is the connecting elbow for joining the water tract to the radiator. This is a cast elbow piece, bolted to the manifold casting, and contains the thermostat unit which shuts off the radiator from the coolant circuit until the specified coolant temperature has been attained. A length of rubber hose connects the elbow casting with the radiator. Attached to the air intake of the carburettor is a cast elbow. On some models this is left open, but on the De Luxe version a Vokes air cleaner is attached. A metal drip tray is fitted under the carburettor, and an A.C. mechanical fuel pump supplies the carburettor with fuel.

Another example of the flat twin cylinder engine, but in this instance air-cooled, is the Panhard and Levassor. The Dyna Model 110 has the two-cylinder opposed engine situated in the conventional position in the front of the chassis. A small Zenith-Stromberg carburettor of the downdraught type is bolted to a casting located above the engine. The casting contains the riser and "T" joint tracts for the induction system, from which a long length of steel tube is led on either side down to the inlet ports at the rear of each cylinder block. These two steel tubes form the induction tract to each cylinder and are unheated, and in order to provide some heat to the mixture, the riser casting is jacketed and fed with exhaust gases by another long steel tube from the exhaust pipe of each cylinder.

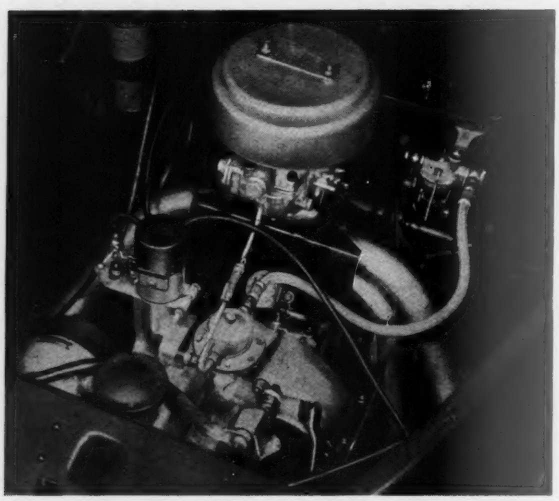
As the induction pipes are so long and the heated area of the riser "T" so short, the ratio of heated to unheated area of the tract is so small that some precipitation might be expected in cold weather. Mounted directly on the air intake of the carburettor is a flat cylindrical air cleaner produced by the Continental Tecalemit Co., while the fuel supply is by mechanical fuel pump mounted on the top of the engine. As the inlet ports are on the rear face of the engine cylinders, the exhaust ports are to the front, and from these separate exhaust pipes lead away towards the rear of the vehicle, where they merge into one before entering the exhaust silencer.

Four-cylinder Induction Systems

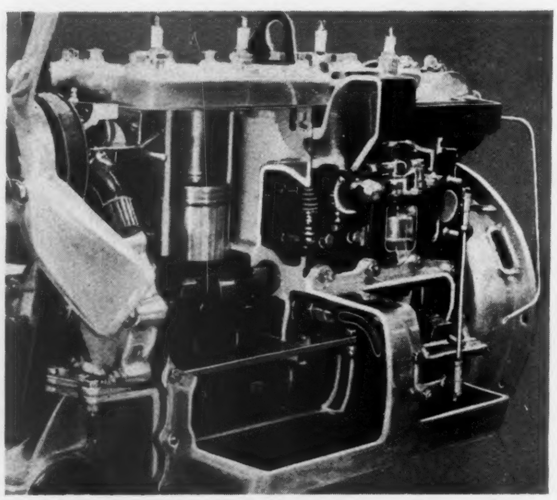
Much variation still exists in the design of induction and exhaust systems. While there are a number of four-port induction systems, it would seem that the two-port design with siamesed ports is the most general. This may be a matter of cost, or in some cases bound up with details of the cylinder head form. An interesting version of the very small four-cylinder induction system is that of the Renault 4/5 cwt. delivery van. This vehicle is equipped with the Renault 760 c.c. O.H.V. engine mounted at the rear of the chassis. Both induction and exhaust manifolds are on the near side of the engine and are two separate castings, and it is surprising to find so small an engine equipped with a thermostatically controlled hot-spot and aluminium induction manifold. A small downdraught Solex carburettor fed by a mechanical fuel pump on the other side of the engine supplies mixture to an exhaust-heated "T" junction, from which the two induction tract galleries lead to the two siamesed inlet ports in the cylinder block.

The galleries are of round section, rising slightly from the riser box to the port branch bends. These bends are almost right angle turns, which fall sharply to the cylinder ports. An exhaust gallery tract from each outer exhaust port rises over the induction manifold, falling again to the centre port, which feed the hot-spot box with exhaust gases. The thermostatically controlled hot-spot takes the conventional form, having a flap valve in the exhaust box below the riser mounted on a spindle parallel with the crankshaft. At the rear, the spindle extends through the box to the outside, and attached to the end of the spindle is the coiled thermostat spring. Thus, the riser "T" jacket is filled with hot exhaust gas when the engine is cold or cool, but when at running temperature the thermostat spring loses tension and the flap valve deflects the exhaust direct into the exhaust system. An air silencer is attached to the side of the engine compartment and a length of rubber hose connects it with the carburettor.

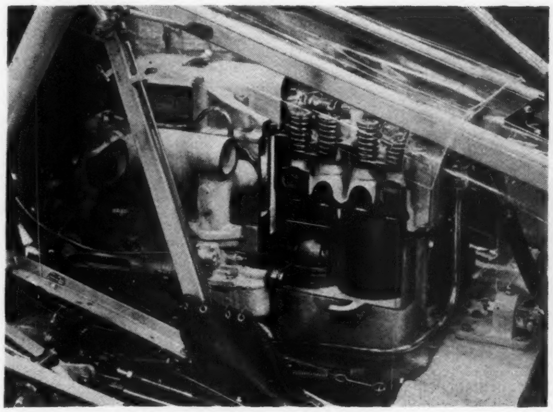
On the larger Renault power unit of 1,003 c.c., which is fitted in the Renault 7 cwt. van, a different induction system is employed. Here the engine is installed in the conventional position in the front of the vehicle, with the inlet and exhaust manifolds situated on the off-side. As before, the two manifolds are separate castings, but the arrangement is quite different. In this



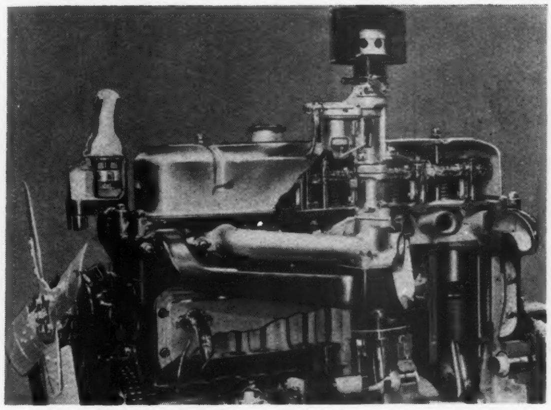
Carburetter and manifolds on Panhard Dyna.



"Scarab" mechanical horse partly sectioned induction system.



Partly sectioned induction and exhaust systems on Guy L.H.D. "Vixen" engine.



Partly sectioned manifolds on Austin 4-litre six cylinder engine.

instance the two manifolds are side by side, the four port exhaust manifold being on the inside, nearest the engine, while the two port induction manifold is on the outside. The inlet and exhaust galleries are thus side by side below the riser, where they are bolted together to form a contact hot-spot.

From this point the round section induction galleries fall from the riser "T" junction to the cylinder ports, where the tracts in the block are siamesed to feed the inlet valve ports.

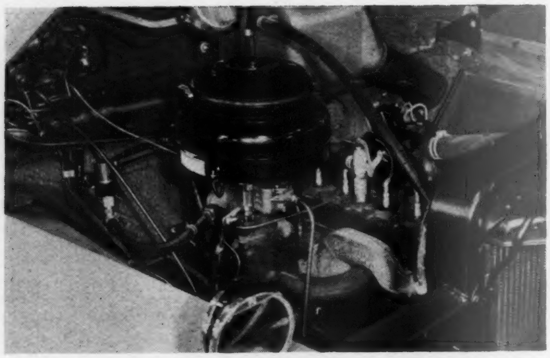
A downdraught Solex carburettor supplies the mixture, and an air silencer of the "T" type is fitted direct to the carburettor inlet. Fuel supply is by a mechanical fuel pump on the opposite side of the engine. It is not very clear why the somewhat costly thermostatically controlled hot-spot is used on one model and not on the other.

Also of the two-port variety are the induction systems of the Ford 5 cwt., and 10 cwt. vans, powered by the Ford 8 h.p. and 10 h.p. engines respectively. These engines have the induction and exhaust manifolds on the near side, the castings being separate, and both of cast iron. With the induction manifold above the exhaust, the two castings are bolted together by appropriate flanges, so forming a contact hot-spot below the riser. A downdraught Zenith "V" type carburettor is bolted to the riser flange, and the mixture passes down and along the rectangular section induction tract to the siamesed cylinder block ports. The gallery on either side of the riser is horizontal and the branch bends are somewhat sharp. From the bend the branches fall some 1½ in. to the ports in the cylinder block. No manifold drains are employed. Mounted on the outside of the crankcase on the same side of the engine as the induction system is the mechanically operated fuel pump. No air silencer is fitted to either model, but a light pressed aluminium cowl is secured over the carburettor intake. This is doubtless a precaution against anything being accidentally dropped into the carburettor intake.

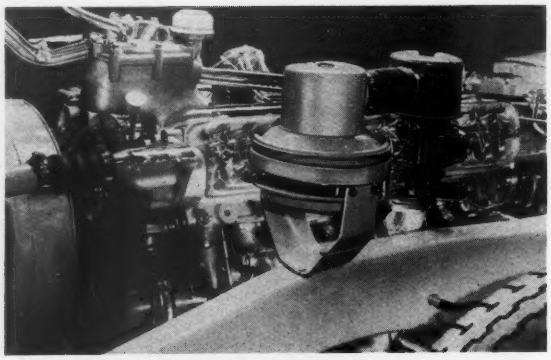
Separate manifold castings with two-port induction are also employed on the Austin A.40 van. Of circular cross section, the induction manifold is on the near side above the exhaust, the two being bolted together below the riser, so that the hot-spot is heated by exhaust gases from the centre exhaust ports. Both the exhaust and induction casting are open inside the jointing flange, and a thin plate is clamped between the two, forming what is known as a "thin-plate hot-spot". In addition, a pressed metal scoop is attached to the lower side of the plate, the object of which is to catch the exhaust gas and deflect it upward against the underside of the plate. The galleries rise slightly from the riser and turn in fairly gentle curves into the port branches, in an almost horizontal plane. A small extension of the induction manifold hot-spot flange is drilled and tapped on the under side to take the manifold drain tube, by which excess fuel lying in the induction system after cold starting may drain away. Fuel supply is by an A.C. mechanical fuel pump on the same side of the engine, and an A.C. "T" type air silencer fits direct to the carburettor inlet.

As the only British-made engine to incorporate the thermostatically controlled hot-spot, the induction system of the 12 h.p. Bedford P.V.C. van is a good example of neat design. Of two-port construction, the induction manifold is placed above the four-port exhaust, the riser and "T" junction being jacketed and supplied with hot exhaust gases from the exhaust system below. Following the conventional design of the thermostatic scheme, a steel flap valve affixed to a spindle in the fore and aft plane directs the exhaust gases around the riser jacket when cold, and directly into the exhaust pipe when hot. This temperature response is obtained by a coiled bi-metal spring, one end of which is attached to the projecting end of the spindle, the other being fixed to the exhaust manifold casting. A bob-weight on the other end of the spindle, together with the off-set mounting of the flap valve, complete the assembly. Of circular cross section, the induction gallery tract on either side of the riser turns towards the block in a wide curve, falling towards the cylinder block ports. The downdraught Zenith carburettor is surmounted by an A.C. air silencer of the "T" type, attached directly to the carburettor intake.

Not all the two-port induction systems have separate castings for inlet and exhaust however. On the Morris Commercial LC-3 25/30 cwt. vehicle, the manifolds are on the near side of the engine but are cast integrally the induction being above that of the exhaust. Of almost square cross section, the induction manifold is joined to the exhaust below the riser, to which a downdraught Solex carburettor is attached. Heat transfer from exhaust to induction thus takes place at the required point. The induction gallery is horizontal and has straight buffer ends projecting some half an inch beyond the junction of the port branches with the main gallery. From the gallery each branch falls some 1½in. to the cylinder block port, where the tract bifurcates to feed each inlet valve. This installation also incorporates a manifold drain, the drain tube being taken as usual from a point in the floor of the induction tract below the riser. No air silencer is fitted, but instead a pressed steel cowl covers the carburettor air intake.



Induction and exhaust manifolds on Studebaker 2R17A engine.



Carburetter, air-cleaner and manifolds on Commer QX engine.

In order to assist in crankcase ventilation, a metal tube is taken from the o.h.v. rocker cover to the carburettor cowl, so that a small depression is imposed upon the inside of the engine.

A smaller product of the Nuffield group, the Morris 5 cwt. vehicle, equipped with the Morris side-valve four-cylinder engine, is fitted with an S.U. horizontal carburettor. Cast in one piece, the induction manifold is of the two-port straight rake pattern with the exhaust manifold below and located on the near side of the engine. Unlike the system employed on the 25/30 cwt. Morris Commercial engine, the gallery tract is of round section. The buffer end projects a short distance beyond the port branches, while the branch ports fall to the cylinder ports as before. A hot-spot is formed by the joining of the two castings opposite the carburettor, so providing heat to assist vaporisation. An S.U. electric fuel pump fitted to the frame furnishes the fuel supply, but here again no air silencer is employed. A rather similar manifold arrangement is used on the Morris Cowley van. An S.U. carburettor of the horizontal type is fitted, together with an air silencer. The connecting channel between the carburettor and the air silencer is rather unusual and takes the form of flat rectangular box of pressed steel. This is done presumably to produce the required air flow capacity while taking up little bonnet space at the side. In this instance also an S.U. electric fuel pump is used, the unit being attached to the dashboard.

Integral manifold castings are also employed on the Commer 25 cwt. Superpoise van, powered by the 16 h.p. side valve Commer engine. A downdraught Solex carburettor supplies mixture to a two-port induction manifold situated above the exhaust on the near side of the engine. In this instance the gallery on either side of the riser starts with a circular cross section, which changes towards the branch bend into a rectangular one, with the major axis in a vertical plane at the bend. The curves of the bends are generous, and between the bend and the cylinder block port the major axis changes again to become horizontal. As is usual with this form of unit construction, the two manifolds are joined below the riser, so that the greatest heat flow takes place at this point.

The four-port exhaust manifold below has its off-take also below the riser, i.e. in the centre of the manifold. From the floor of the induction tract at this point is taken the manifold drain. A brass union piece with a right angle bend is screwed into the side of the manifold casting, from which the drain tube is led down clear of the crankcase. A refinement in the drain system, to be found on all the larger engines of the Rootes group, is the aluminium ball valve fitted to the bottom of the drain tube. The device is so designed that when the engine is stopped, the ball drops down against a stop pin and leaves a large orifice for drainage. When the engine is running, however, the depression in the induction system holds the ball up against its seat, so cutting off any air leak and preventing instability when idling. An A.C. fuel pump of the mechanical type is fitted to the crankcase on the same side of the engine, and is shielded from heat radiated by the exhaust manifold by a steel-asbestos plate. In place of an air silencer, a pressed metal cowl is affixed to the carburettor intake by two studs.

A somewhat different form of induction system is to be seen on the Guy L.H.D. Vixen, where the induction gallery is cored within the cylinder block. Situated on the near side of the engine is the four-port exhaust manifold, and cast integral with the manifold is the vertical updraught carburettor riser and right angle elbow branch. This branch bolts up to the cylinder head, and aligning with a cored channel leading into the internal four-port gallery tract, forms the induction system. The riser and elbow portion of the exhaust manifold casting are on the underside of the manifold, so that a hot-spot is formed. A vertical Zenith "V" type carburettor is installed, rather surprisingly, with the float chamber to the rear. This arrangement is somewhat unusual, the most common position for the float chamber being to the front. As the carburettor is an updraught, it would be expected that the mixture would lean off when climbing a steep hill. This is one of the few vehicles employing an Autovac for the fuel supply. It is mounted on the dashboard.

At first glance the induction system on the Vulcan CVFA vehicle would appear to be of the two-port variety, but in actual fact it has four ports. This four-cylinder engine has both manifolds on the near side of the engine. The inlet is above the exhaust, and the two are joined as usual in the centre below the carburettor. The induction manifold is straight, of round section with buffer ends. Two wide port branches fall gently from the gallery to the cylinder block, but each branch contains two cored tracts, which align with the four inlet ports in the cylinder block. The exhaust manifold below is heavily ribbed in the horizontal plane, with the exhaust off-take to the rear. A Solex carburettor of the downdraught pattern is employed, with a simple pressed metal cowl instead of an air silencer. Fuel supply is by an A.C. mechanical fuel pump.

Conventional four-port design is employed by Scammell on the Scarab Mechanical Horse. This side - valve power unit has the two manifolds cast in one piece being joined in the centre as usual, but here the induction is below the exhaust. Of round cross-section, the induction gallery is of the straight-rake pattern, with buffer ends about one inch long. The four port

branches are arranged in pairs fairly close together at each end of the gallery, and rise some two inches to the cylinder block ports. A horizontal Zenith "V" type carburettor feeds the centre of the gallery, and a large air cleaner mounted on the chassis is connected to the carburettor intake by a length of rubber hose. Underneath the carburettor is a drip-tray from which a drain tube is taken down below the crankcase. The large rectangular-section exhaust manifold is of the four-port type, the off-take being at the front, from which the exhaust pipe leads down to the silencer alongside the gear box. In place of the usual strangler valve the Zenith carburettor is fitted with a small auxiliary carburettor for cold starting.

Six-cylinder Induction Systems

As in the case of the four-cylinder engine, induction and exhaust systems vary a great deal. Widely different schemes are employed all apparently giving excellent results. Gallery tracts may be round, rectangular or any combination of the two, port branches may rise or fall between the induction gallery and the cylinder block port. Gallery tracts themselves may be horizontal, or may tilt up at each end from the riser to the end branch ports. Port branch bends may be gentle curves or sharp right angle turns. Buffer ends up to an inch or more in length are often employed, usually with a flat induction gallery of the straight-rake type. While the great majority of induction systems are formed by separate external manifold castings, a few engines have the main gallery and port branches cored inside the cylinder block.

Again, some difference of opinion evidently exists in the matter of heat and its application to the induction system. While there are a greater number of exhaust-heated hot-spots of varying designs, there are a few installations employing water heat from the coolant system. In the main, however, it would appear that the most popular six-cylinder arrangement is the three-port system, mounted above the exhaust manifold, with an exhaust-heated hot-spot at the junction between the two. Next in order would seem to be the six-port system, with the four-port type running last. It should perhaps be mentioned that there were more four-port induction systems at the last Motor Show on private car engines.

Among the newcomers to this year's Commercial Show is the 300 cu. in. Bedford engine, of which a polished and sectioned version was exhibited on the stand. Following usual Bedford practice, the inlet and exhaust manifolds are on the near side of the engine, the inlet being above the exhaust. A radical departure has been made in the cylinder head porting arrangement. Whereas the previous Bedford six-cylinder engine had a four-port exhaust manifold, with the centre pair extracting from siamesed exhaust ports the new engine has six separate exhaust ports. The exhaust manifold is thus a six-port one, and is situated below the three-port induction.

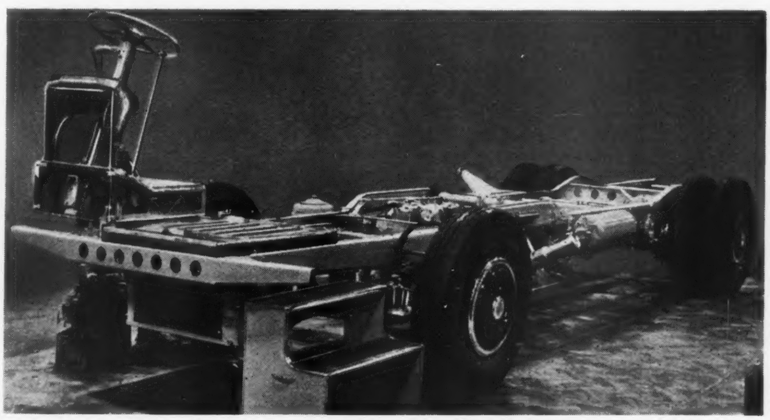
Both manifolds are of cast iron, and a "hot-floor" hot-spot is arranged at the point where the two manifolds are bolted together, on either side of the junction of the riser and gallery tracts. The flange of the exhaust casting is open so that exhaust gases play directly upon the floor of the induction tract underneath the riser. Like the earlier Bedford engine, the cross-section of the gallery tract is ⌂ shaped, From the "T" junction the gallery tracts rise about an inch and then fall gently towards the port branch bends. As the cylinder block ports are approached, the section changes from ⌂ to round.

Incorporated in the downdraught Zenith carburettor is an air flow and spring controlled speed governor, which forms part of the throttle valve. The carburettor itself is of the economiser and accelerating pump type. Induction depression is employed to operate the A.C. crankcase ventilation system. For this purpose a metal tube about $\frac{3}{8}$in. outside diameter is taken from a point in the riser just below the carburettor to the push-rod cover on the other side of the engine, and a special valve is incorporated in the system. Mounted on the off-side is the A.C. fuel pump, to which is attached a glass-bowl petrol filter.

Austin retain the three-port induction on the four-litre engine which forms the power unit of the K-2 and K-3 vehicles. A downdraught Zenith "V" type carburettor feeds the round-section induction system, which is mounted in the conventional manner above the exhaust manifold, which is of the four-port pattern. The induction galleries rise slightly from the riser towards the branch bends, which turn fairly sharply in towards the cylinder block. A feature of this design is the use of a "thin-plate" hot-spot, arranged between the connecting flanges of the two manifolds where they are bolted together, below the riser. In common with nearly all the engines exhibited, an A.C. fuel pump is employed.

Ample heat to the mixture is evidently the aim in the design of the manifold system on the Commer six-cylinder side-valve engine in the Superpoise 3-4 tonner. Not only is a hot-spot provided, but in addition the downdraught riser is taken down through the exhaust manifold, which in this installation is placed above the inlet. The three-port induction manifold itself is of cast iron, the gallery tract rising slightly from the centre. Of rectangular section, the major axis is horizontal under the riser, changing to the vertical at the outer branch port bends, and changing again to the horizontal at the cylinder block ports. This alteration of the tract cross-section has long been a feature of products of the Rootes group.

As the two manifolds lie close together, the four-port exhaust gallery also rises from the centre towards the end port branches, the exhaust off-take being taken from a point just in front of where the riser passes down through the exhaust-jacketed riser. An A.C. fuel pump on the same side of the engine supplies the downdraught Solex carburettor, and in addition to a thick asbestos heat-insulating gasket between the carburettor and the riser flange, a metal heat deflector plate is also fitted.



Guy "Arab" underfloor engine chassis.

No air silencer is employed but a metal cowl is arranged over the carburettor air intake.

Of the American designs, both Studebaker and Dodge favour the three-port design, but only Studebaker incorporate the thermostatically-controlled hot-spot. The Studebaker model 2R10, equipped with the smaller six-cylinder engine, employs cast iron for both manifolds, the induction being placed above the exhaust on the off side. With this form of hot-spot, so widely popular in the United States, the junction of the riser "T" and the main gallery is jacketed and open to the exhaust, where the two manifolds are bolted together in the centre. Arranged in the exhaust tract below the induction is a sheet steel flap valve, mounted on the spindle placed parallel with the crankshaft. On the Studebaker the spindle projects out through the casting in the front, and a coiled bi-metal thermostat spring is attached to the spindle by its inner coil and to the manifold casting by its outer one. The effect of this is to hold the flap valve in such a position when cold as to direct the exhaust gases round the riser jacket, so providing the maximum amount of heat to the mixture.

As the engine and manifolds warm up the thermostat spring picks up heat also, and so loses tension, gradually permitting the flap valve to rotate and direct the exhaust gases away from the riser jacket and into the exhaust manifold direct. The off-set mounting of the flap valve and the use of a bob-weight on the other end of the spindle ensures the required operation. A noticeable feature of the Studebaker 2R10 system is the fact that the front induction gallery rises from the "T" junction to the cylinder block port more than does the rear gallery. This is doubtless the result of development work upon mixture distribution. A Carter downdraught carburettor is used, to the air intake of which is attached a large cylindrical air silencer. The starting system of the carburettor is by off-set strangler valve. Petrol filtration is provided for by the separate glass-bowl filter attached to the mechanical fuel pump.

Regarding the Studebaker 2R17A-55 model equipped with the larger power unit a different type of induction arrangement is used. While both manifolds are of cast iron and mounted on the off-side as before, the exhaust system is partly above the induction. The centre exhaust ports feed into the thermostatically controlled box. but the two exhaust galleries from the outer ports rise over the induction manifold and fall to join the centre port tracts. As before, the induction system is of the three-port, round section variety, the front gallery rising more to the front cylinder port than the rear. Here again, a Carter downdraught carburettor with hand-controlled strangler and linked fast idle, is employed, and a large oil-bath air cleaner is fitted to the carburettor intake.

On the side-valve engine forming the power unit of the Dodge 6-tonner, model 123, the cast iron three-port induction system of previous years is retained. Arranged on the off side of the engine, the two manifolds are separate castings, the three-port inlet being above the four-port exhaust. The riser "T" junction is exhaust jacketed, but there is no thermostatically controlled hot-spot as in the case of the Studebaker. This installation incorporates a Ball and Ball carburettor with hand strangler and linked fast idle. On the same side of the engine but below the manifold is the mechanical fuel pump. As this is somewhat close to the exhaust system the pump is protected from radiated heat by a metal asbestos shield.

A newcomer from the United States, the new Reo Gold Comet, presents some interesting features. In this new large o.h.v. engine the induction gallery is of rectangular section and is cored within the cylinder head, running horizontally over its entire length. From this gallery the six branch ports fall to the individual inlet valve. The gallery is fed by a downdraught Ball and Ball carburettor through an exhaust heated riser piece in which is cored a right angle bend tract, which aligns with the channel passing across the block to meet the main induction gallery. The riser piece is a separate casting and is attached to the top of the exhaust manifold by bolts.

A refinement here is the manually operated exhaust gas flap valve known as the "vaporizer heat control", which serves as a seasonal control of the hot-spot. The spindle of the valve carries a slotted lever on the outside of the casting. The slot fits over a stud and is secured in the required position by a nut, so providing a summer and winter condition by the position of the flap valve by directing hot gases into or away from the riser junction jacket. Interposed between the carburettor and riser flanges is an air flow and spring-controlled Hardy speed governor. The Ball and Ball carburettor is equipped with hand operated strangler valve and fast idle, and a large oil-bath air cleaner is fitted direct to the top of the carburettor.

While the Commer QX six-cylinder "underfloor" engine is not flat, it is nearly so, the centre line of the cylinders being some 66 deg. from the vertical. Both induction and exhaust systems are of the six-port type and are on the underside of the engine. A downdraught Solex carburettor is mounted on top of the riser piece, which then bends down and inwards towards the engine to join the main induction gallery. A "thin plate" hot-spot of large area is provided between the jointing flanges of the two manifolds, and from this point a manifold drain pipe is taken down below the engine. The main induction gallery being horizontal, the six-port branches curve upward from the gallery to the cylinder block ports. Both gallery and branch bends are of round section, the induction casting being of aluminium. A cylindrical capacity box is fitted at the carburettor entry, from which a corrugated rubber hose is taken to the oil-bath air cleaner mounted on the frame.

Also unchanged is the six-port induction system employed on the six-cylinder o.h.v. Daimler Ambulance engine. Although both inlet and exhaust manifolds are on the same side of the engine, exhaust heat is not used for the hot-spot. Instead, the aluminium induction manifold casting is jacketed over its entire length and is in circulation with the engine coolant system. Owing to the close proximity of the six-port exhaust manifold which lies just underneath, the induction system must pick up a good deal of heat by radiation. A downdraught Solex carburettor is mounted in the centre of the gallery, with a metal-reinforced asbestos heat shield clamped between the connection and the riser. An A.C. air silencer of the "L" type lies across the engine, with its elbow attached to the carburettor air entry by a short length of rubber hose. In external appearance the induction gallery is D shaped, with the curved side towards the engine. Actually the cross-section of the induction gallery within is circular, while the port branches are of rectangular section. The branches rise somewhat sharply to the ports in the block. As the engine has a small inclination downwards at the rear when installed in the chassis, the manifold drain tube is taken from the rear end of the manifold.

Among the new six-cylinder engines exhibited for the first time, the new Morris Commercial o.h.v. 4¼-litre power unit incorporates the four-port system. A downdraught Solex carburettor supplies mixture to a straight-rake induction system of round section. The main gallery has extended buffer ends, and the four branch ports fall to the block, changing to rectangular

section. Located underneath is the five-port exhaust manifold, an extension from the centre port being bolted to a flange on the under side of the induction gallery, so providing a contact hot-spot. From this flange on the induction casting a manifold drain tube is taken, the flange being drilled and tapped for this purpose. Other equipment includes an oil bath air cleaner mounted direct on the carburettor, and a fuel pump of the mechanical type fitted to the rear of the crankcase, on the same side as the manifolds.

Eight-cylinder Induction Systems

Undoubtedly the most popular eight-cylinder engine is the V.8, and a good example of this is on the Ford Thames heavy duty pick-up. Here a dual downdraught Solex carburettor is employed, each throttle barrel of which supplies a separate induction tract. The whole induction system is ingeniously arranged in a single casting fitted over the top of the vee, the tracts being such that one throttle barrel and tract feeds the two outer cylinders on one side, and the two inner ones on the other. The tracts have therefore to pass over one another, but the whole design is compact and neat. Fuel supply is by a mechanical fuel pump located high up at the rear of the engine, and a large cylindrical oil-bath air cleaner fits direct on to the carburettor air intake.

In conclusion, it may be noted that, while at the last Commercial Motor Show two petrol injection systems were exhibited, no such devices are shown this year.

CLUTCHES

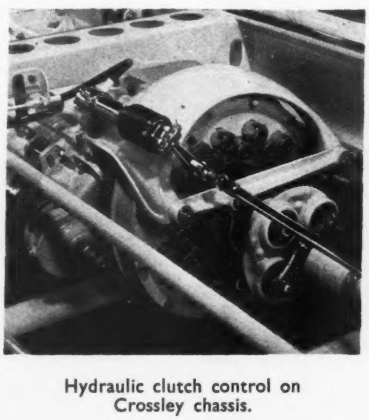
A High Degree of Standardization

SINCE the last Show, clutch design has, if anything, become still more standardised. The single dry disc, nearly always of Borg and Beck design and manufacture, is almost universal. The twin disc clutch used by the Crossley Company last year has, for example, now been given up in favour of a single disc unit. Dennis, who make their own clutches, still use a twin disc clutch on the heavier models, employing a single disc 13¾in. in diameter on the 7-ton "Centaur" and the "Falcon" passenger chassis. Among the exceptions is the Thornycroft "Antar", in which the Meteorite diesel engine develops 250 b.h.p. and a maximum torque of 728 lb. ft. The design of the crankshaft of this engine, which is based on aircraft practice, does not make the fitting of a heavy flywheel to the crankshaft desirable. The clutch is therefore housed in a separate unit with its engine driven member carried on its own bearings connected to the crankshaft by an internally toothed muff coupling. Two discs 18in. in diameter are employed, of Borg and Beck design. Clutch operation is assisted by an air pressure servo, and a fan is provided for cooling.

On one of the Crossley chassis the single disc Borg and Beck clutch, which is connected to a separate gearbox, is without the usual bell housing, the customary outboard bearing being absent. The spinning member of the clutch complete with the front Layrub universal joint is carried by the engine crankshaft. Withdrawal is by a swinging forked lever operated by a Lockheed hydraulic cylinder, this being apparently the only example of hydraulic clutch operation. The Daimler bus chassis still has Lockheed hydraulic servos connected in the rodwork of the Wilson gearbox bus bar operating mechanism.

Among the firms who continue to make their own clutches are Fodens Ltd. The disc, 15¾in. in diameter, has a separate cast iron lining for the flywheel face and the withdrawal levers are carried by the pressure plate. They are pulled outwards to release the clutch when their outer ends bear through adjustable setscrews on the heads of hardened screws tapped into the casing. A ball journal withdrawal bearing race with a stationary outer casing is fitted and this carries an annular friction disc making contact with a disc keyed to the mainshaft to form a clutch stop. On the rear-engined Foden chassis, the splined clutch shaft passes through a sleeve carrying a bevel pinion which in turn drives a bevel wheel on the first motion shaft of the diagonally located gearbox. By removing a cover the clutch shaft can be drawn out laterally. After detaching the securing bolts through a large opening cored in the bell housing, the whole clutch assembly can be removed without disturbing the engine or the gearbox.

Cushioned clutch discs are frequently employed though the new 7-ton Bedford has what is substantially a solid disc, the facings, however, being of the woven type, which in itself gives a certain amount of elasticity. Spring centres to absorb torsional vibration are very general, and are fitted to this Bedford clutch and to most of the Borg and Beck units. Another popular clutch centre is the Donflex, in which the facings are attached to two slightly dished steel spiders and secured by what could be called cork rivets. A valuable degree of cushioning is afforded by the cork and the dishing of the steel centres.



Hydraulic clutch control on Crossley chassis.

The fluid flywheel, which may be properly considered under the heading of a clutch, is to be found associated with Wilson gearboxes on A.E.C., Daimler and Guy chassis, among others. The A.E.C. flywheel has cast steel members with plain radial vanes without any torus but with a small flat baffle plate to adjust the characteristics of the unit. Packed glands are generally used on fluid flywheels, though the torque converters now becoming so popular in America have synthetic rubber oil seals at this point.

The operation of the clutches and brake bands of Wilson boxes can also be said to come under the heading of clutch mechanism and takes two forms. In the case of A.E.C. and Guy chassis, for instance, the bus bar spring is omitted and its place taken by an air cylinder with a weak return spring. This is piped to a control valve, generally mounted on the end of the air reservoir and linked by rodwork to the gear pedal. General practice is to place a reducing valve in the circuit, the bus bar cylinder being supplied with air at about 47 lb. per sq. in. One of the objects is to ensure that consistent operation of the Wilson box is obtained in spite of a possible drop in the air reservoir pressure. On the Daimler bus chassis the bus bar spring is retained and operation is by

rodwork with a Lockheed hydraulic servo introduced in it. Here, of course, consistency of operation is ensured because the bus bar spring is the operative member.

The Hobbs semi-automatic transmission can be taken as a special case of clutch mechanism embodying, as it does, two hydraulically operated disc clutches and three hydraulically operated disc brakes. The clutches have cast iron pressure plates and asbestos fabric facings on the disc. They work in a semi-lubricated condition, but are not immersed in oil. Smooth engagement has been ensured by providing radial grooves in the facings, extending to the outer edge but stopping short of the inner diameter. On engagement these grooves allow the oil to escape centrifugally, while the blocked inner ends prevent fresh oil reaching the surfaces from the leakage supply at the hub. The three disc brakes have the facings on pressure plates and the steel discs have radial slots to allow escape of oil.

GEARBOXES

New Designs of Semi-Automatic Mechanisms

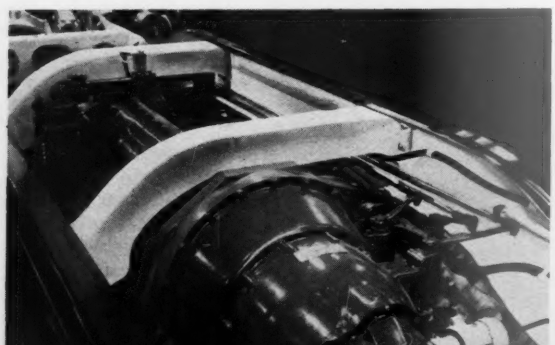
THE Brockhouse Salerni torque converter shown at the last Show on a Crossley chassis, was not in evidence this year, and no example of this type of transmission was exhibited. In America it is said to be widely used not only for private cars but also for urban delivery vans making frequent stops. Whatever its merits on a long distance vehicle not making frequent gear changes, the system has obvious advantages for city work. Apart from the torque converter, a most important step forward in transmission is the development of the Hobbs semi-automatic four-speed gearbox, which has now reached the installation stage on the Dennis "Dominant" chassis.

Another promising scheme is that sponsored by the Self-Changing Gear Company, and consists of a Wilson gearbox with pneumatic operation of the clutch and brake bands under control of electrically operated valves worked through timed and controlled relays. This gives, if desired, fully automatic action with driver control as an alternative. Direct compressed air operation of a Wilson box by individual cylinders is also shown. This has, of course, been used for some time on rail cars. The more orthodox Wilson boxes are still to be found with bus bar operation by compressed air, as on the A.E.C. or by spring with hydraulic servo, as on the Daimler.

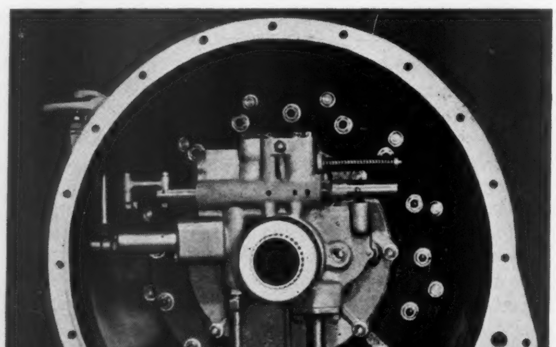
The de Normanville overdrive was shown on the stand of the Laycock Engineering Company. Since this is a small size unit it will be dealt with more fully in the report of the private car Show. It is a relatively simple two-speed epicyclic overdrive with finger-tip operation from the change speed lever knob. Cone clutches and a free-wheel pick up the load and prevent racing of the engine when changing down.

The tendency to provide more than four speeds which was noted in the 1948 Show Report, still continues. New five-speed boxes were shown by Crossley and Tilling-Stevens, among others. New auxiliary gearboxes were to be found on Foden overseas models, on a Morris-Commercial and on the Thornycroft "Antar". A range of auxiliary gearboxes was shown by M. O. Harper Ltd., one of these being available with a power take-off for front wheel drive as well. While the two-speed Eaton back axle is in some cases deferring the fitting of a five-speed gearbox, there are several instances of this axle being supplied where a five-speed box is already installed. Synchromesh is gaining some ground. The new 7-ton Bedford chassis for example, embodies this on three out of its four speeds, but many of the new boxes have internal tooth dog clutches without synchronising mechanism.

As mentioned in our issue for November, 1948, the Hobbs transmission is of the epicyclic type, the gearing consisting of triplicated layshafts with three wheels on each, meshing with three sun wheels and mounted in a planet carrier. The planet carrier is connected to one of two clutches in the engine flywheel, while one of the sun wheels is connected to the other. The planet carrier is also connected to a disc brake in the main housing, while two

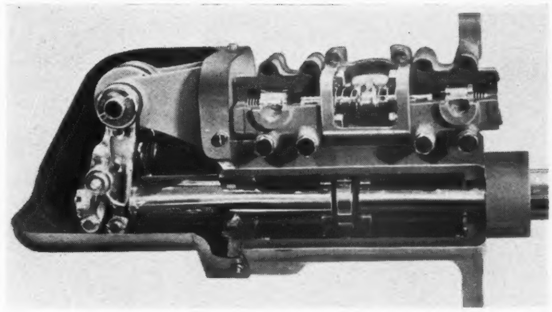


Hobbs semi-automatic epicyclic gearbox on Dennis "Dominant" chassis.



Control mechanism and relief valves of Hobbs semi-automatic epicyclic gearbox.

Epicyclic unit of Hobbs gearbox.



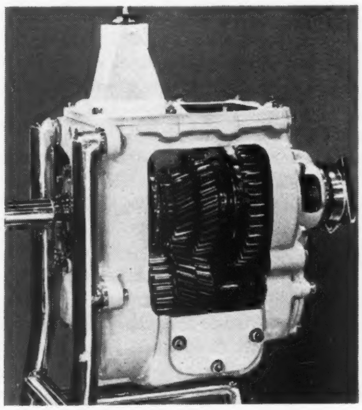
Clayton-Dewandre air servo for change-speed.

other disc brakes also pick up two of the sun wheels. The final drive is taken from the third sun wheel at the rear.

The power in all cases has to pass through one or other of the clutches. When both are engaged simultaneously the epicyclic is locked solid and direct drive is obtained. The three lower gears and the reverse are obtained by applying one of the brakes in conjunction with one of the clutches. The brakes and clutches are very similar in construction, with asbestos facings and cast iron pressure plates for the clutches and asbestos facings gripping steel discs in the case of the brakes.

Application is by oil pressure behind synthetic rubber diaphragms reinforced with canvas, pressures being about 50 to 60 lb., except first speed and reverse, in which case 200 lb. per sq. in. is necessary on account of the higher torque that has to be taken. Oil is supplied by two pumps, one driven direct from the engine and the other from the output shaft, this being provided to give oil pressure if the vehicle has to be towed to start the engine. Supply of oil in the proper sequence to the various clutches and brakes is provided by a single cylindrical valve with suitable ports connected to a small lever on the steering column. Since the oil flows radially outwards from the centre to the rotating clutches, it would build up a pressure by centrifugal force, which would prevent release of the clutch unless special means are provided.

This takes the form of a radially moving floating valve with a weak spring moving it outwards. This

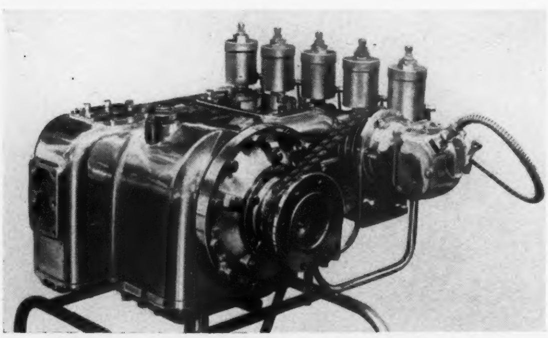


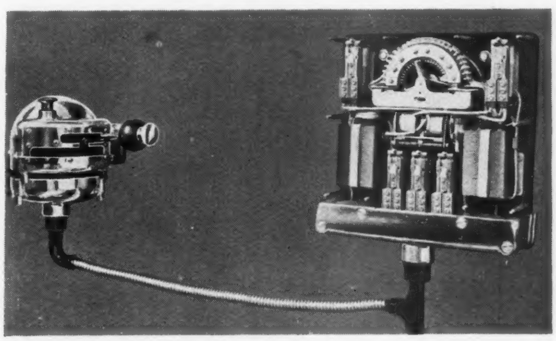
7-ton Bedford synchromesh gearbox.

valve unless driven inwards by the pressure of oil supplied by the pump, normally occupies an outward position in which it uncovers ports by which the oil can escape directly into the clutch housing. Connected to each of the chambers behind the clutch actuating diaphragms are additional valves known as trafficating valves, which have the effect of allowing exhaust of the oil until the engine speed rises to something beyond a "tick over". Should the engine come to a dead stop these valves move still further inwards and close the ports again, enabling pressure to be built up for a re-start by towing. In normal driving the action of the trafficating valves is to disconnect the particular clutch or clutches which happen to be engaged when the engine slows down to a tick over. No pedal disengaging mechanism is therefore necessary, and the driver can bring his vehicle to rest without stalling the engine in any gear he likes.

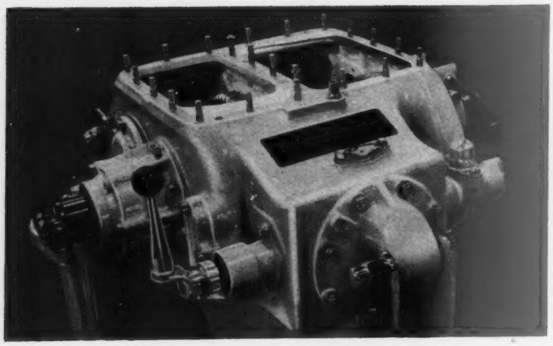
On the Dennis "Dominant" chassis the control lever works in a little gate on the steering column housing, but this has slots of different lengths and involves no cross selection, the gate slots merely serving as limit stops to locate the control valve in the various positions for the different gears. The oil pressure to the clutches is normally held at a fairly low figure, about 50 lb. per sq. in., by a relief valve. The spring of this relief valve is connected by a lever to the accelerator pedal in such a way that for small throttle openings or for small injection settings, in the case of a diesel engine, the pressure is reduced, being allowed to build up to its maximum as full throttle is given and full torque applied.

Some of the brakes which hold the epicyclic members stationary, in particular first and reverse brakes, have

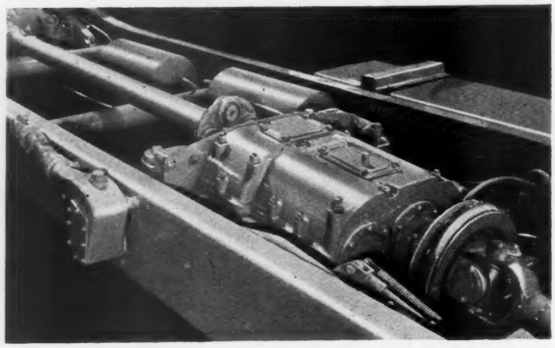




Self-changing Gear Company's automatic Wilson gearbox (left) with manual control and electrical relays (right).



Guy four-speed gearbox.



Gearbox and control on Tilling-Stevens double-decker bus chassis.

to take very high torques. This is dealt with partly by duplicating the friction disc assemblies and partly by a special spring-loaded relief valve travelling over ports, some of which are closed when reverse or low gear is engaged. The valve then has to travel further before opening an escape and a high pressure is thus built up, appropriate to the torque that has to be taken.

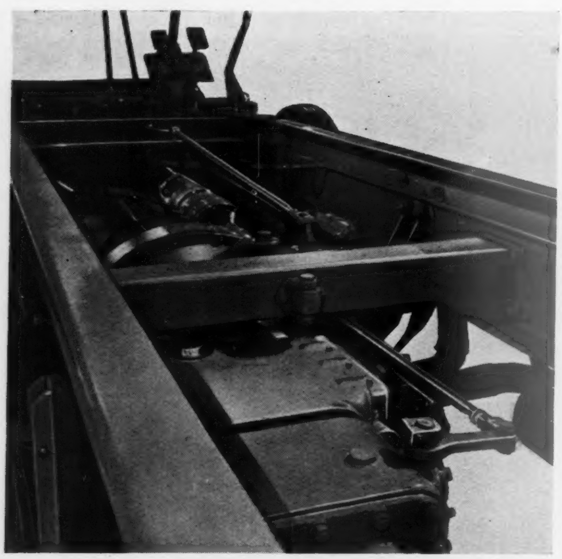
It will be understood that when in use for the lower gears, the brakes are always fully engaged before the clutch or clutches take up their work and there is therefore normally no slip in these members, all the slip taking place in the clutches, which are under the control of the trafficating valves in addition to the hand lever. The engagement of the clutch is sufficiently soft to enable changes of gear to be made up or down without releasing the throttle. The gear is, of course, not fully automatic, but does not require the operation of any clutch pedal. The ratios in a typical bus box work out at top 1 : 1, third 1.62 : 1, second 2.62 : 1, first 4.72 : 1, reverse 5.01 : 1.

While apparently rather complicated many of the discs and annular shaped parts of the clutches and brakes are interchangeable, while the layshaft type epicyclic train is exceedingly simple for the number of ratios provided. Among the advantages of the gear is the fact that the epicyclic train is at rest when the vehicle is stationary, the disconnection of power taking place at the clutches in the engine flywheel and not in the box itself, as with other epicyclic gears. There is therefore no noise of "planetating" gears when the vehicle is standing with the engine running.

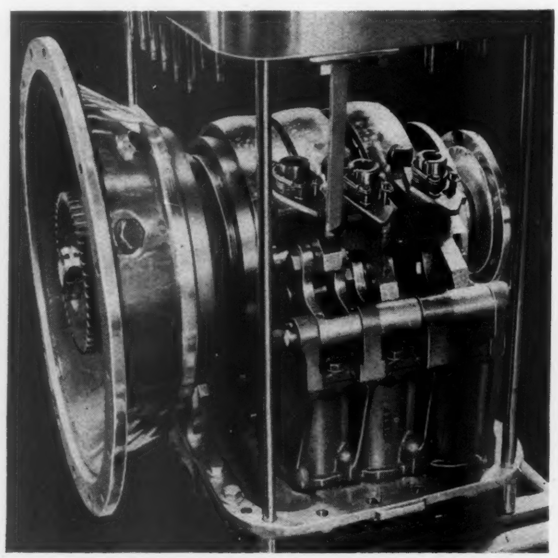
In the automatic electrically controlled gearbox produced by the Self-Changing Gear Company the top speed clutch and each brake band has its own air cylinder supplied by an individual valve controlled by a solenoid. These solenoids can be operated by a manually controlled switch of the gate type to select any gear desired. In one position marked "auto", however, the master switch hands over the control to a governor switch driven off the output shaft. This governor is also connected to the throttle in such a way that change of gear can be made a function of both engine torque and output shaft speed.

Any desired compromise can be made by altering the shape of a cam plate that is operated by the governor. Suitable delay actions to leave, for example, a lower gear partially engaged while a higher gear is taken up, are provided in electrical fashion with electrolytic condensers, with or without shunts across the solenoid coils. Electrical delay also is arranged to prevent too rapid succession of changes. While yet in the early stages it is clear that the principle is capable of considerable development.

The Self-Changing Gear Company also exhibited a Wilson box more particularly suitable for rail cars in which the electrical control gear is



Main and auxiliary gearbox on Sentinel chassis.



Air-operated Wilson railcar gearbox.

omitted, but each brake band or clutch has its own air cylinder and toggle mechanism connected by pipes to an air control valve in the driver's cab. As previously mentioned, the Wilson gearboxes on buses are all provided with some form of servo assistance either compressed air acting on the bus bar or hydraulic servo acting on a bus bar spring. Daimler offer a Wilson gearbox providing five speeds. Normally four speeds are provided with this mechanism.

The new Crossley five-speed gearbox is arranged to give an overdrive on top gear and has intermediate bearings to both main and driven shafts. It has been found possible to design this box for assembly without splitting the case in two halves, thus providing a very rigid construction. All bearings are carried in steel housings pressed into the aluminium case. The teeth are straight and are ground and in constant mesh for overspeed, third and second gear, the idle wheels running on needle roller bearings and being engaged by internal toothed clutches without synchromesh mechanism. Spring plungers are provided for the three striking rods, but a caliper type interlock is provided. The selecting shaft is carried in two bushes on either side of the finger and is intended to be coupled to the change speed lever by a universal jointed tube.

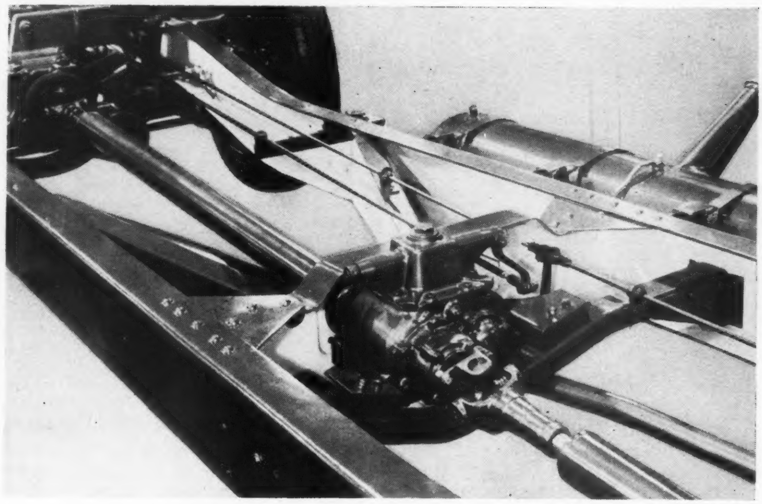
The new Tilling Stevens five-speed box is direct on top gear, has helical teeth on third, fourth and constant mesh wheels, engagement of all the first, second and reverse gears by internally toothed clutches without synchromesh, intermediate bearings and a split aluminium box. This particular box is used on a normal control vehicle with the gear lever mounted direct on it.

The Foden overseas model has a four-speed gearbox with helical gears for second and third speeds running on Hoffman roller bearings in cages, engaged by internal toothed clutches without synchromesh. To the rear of this box is attached an epicyclic box giving a reduction of 3.29 to 1. The sun wheel is splined to the driven shaft while the annulus is sandwiched between the two halves of the housing. The planet wheels run on roller bearings on studs holding together the two halves of the planet cage, which runs on roller bearings on races ground on the hub of the sun wheel.

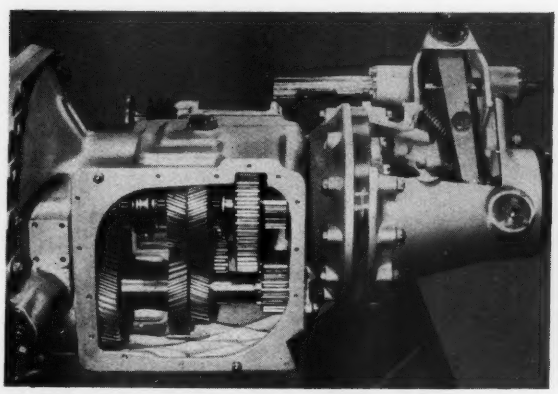
The final output shaft is carried on a ball bearing on the end of the extension shaft and has its front end supported by a roller bearing spigot integral with the gearbox driven shaft. Sliding on splines on the output shaft is a muff with external clutch teeth engaging with internal teeth cut in the hub of the sun wheel, or with similar teeth cut in an extension of the rear half of the planet cage. This muff is actuated by a lever worked by a throw over toggle spring and a separate hand lever. In operation the driver throws over the lever and the cone comes out of engagement as soon as the load is released, meshing with the other set of teeth as soon as synchronism has been obtained. The action is similar to that of the Maybach gearbox, but there is not in this case the special backing off of the clutch teeth which facilitated changing so much.

The six-cylinder Morris-Commercial overseas chassis has an auxiliary two-speed gearbox neatly bolted to the cross member of the main frame. Auxiliary gearboxes were also offered by M. O. Harper Ltd., one of which had a power take-off incorporated to take the drive to a driven front axle also provided by the firm.

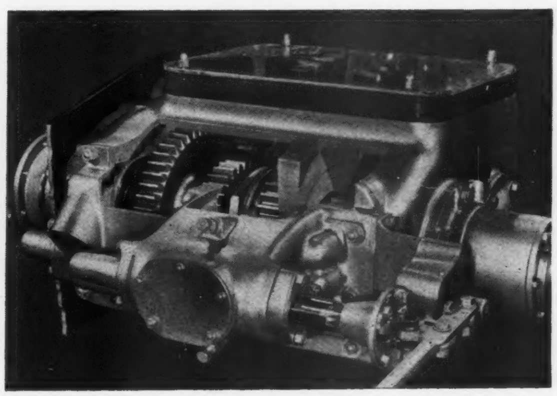
The Thornycroft "Antar", which has a 250 h.p. engine, has a four-speed and reverse constant mesh gearbox bolted up integral with the housing containing the twin disc 18in. clutch. To the rear of this four-speed gearbox is bolted another three-speed auxiliary box giving an overdrive of 0.735 to 1, normal-direct, and an underdrive of 1.728 to 1.



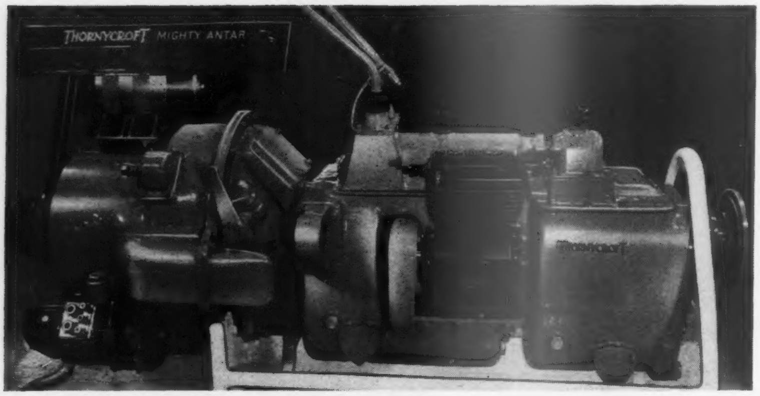
Auxiliary gearbox on Morris-Commercial chassis.



Foden four-speed gearbox with epicyclic auxiliary.



Crossley five-speed gearbox.



Clutch, main and auxiliary gearbox unit of Thornycroft "Mighty Antar".

Among the multi-speed gearboxes to be found on vehicles intended for cross country work and requiring a wide range of speeds is the Scammell six-speed gearbox, one of the pioneers of its type. This gives six indirect gears with only eight gear wheels and has been produced without any modification whatever for the past fifteen years or more. In this gearbox the four pairs of gears are first used one after the other in sequence to give the four higher gears, and are then compounded up and down again to give two additional low gears. All idle wheels run on needle roller bearings and are engaged by internal toothed dog clutches. Pump lubrication is provided to ensure that only an oil spray is provided, and the gears are not so deeply immersed as to absorb a lot of power in oil churning.

The new four-speed box of the new 7-ton Bedford has baulking ring type synchromesh on second, third and top gears. Top and third mechanism is the type familiar on private cars, but in the case of the second speed the synchronising cone is inside the first speed sliding wheel in which it is loosely secured by a circlip. Two long tongues working in two shouldered keyways in the second speed wheel provide a synchronising drive and lock, the engagement being by internal teeth broached in the hub of the first speed wheel on which it slides on the similarly toothed driven shaft.

The great length of the change speed control rods and the massive dimensions of some of the larger gearboxes, especially on cross country vehicles, would seem to suggest the desirability of power assistance for an ordinary gear change. While there was no vehicle so equipped in the Show, Clayton-Dewandre had on their Stand a compressed air servo to assist in gear changing. In this the hand lever is connected to the inner of two concentric tubes, the outer of which carries a double-acting piston working in a cylinder with the usual end glands. Slight relative movement between the two tubes operates through links similar in principle to those on a Clayton-Dewandre vacuum servo, a set of floating valves admitting or exhausting the air to either end of the cylinder as required.

PROPELLER SHAFTS

Standardization of Proprietary Units

NEARLY all propeller shafts in the Show are either the Hardy Spicer needle roller bearing component or Layrub by the Laycock Engineering Company. Several chassis fit the Layrub Victor type of joint as made in the larger sizes, in which the rubber bushes, instead of being carried by detachable bolts were fitted on stubs made integral with the arm stampings. This generally implies fitting flanges to the outer halves of the joint to enable the shaft to be detached without withdrawing the rubbers from their seatings.

The Hardy Spicer joints continue to embody companion flanges to assist in dismantling without exposing the needle roller bearings. The Company have just introduced a very large size of joint called Type 1900. This has a low gear torque capacity of 52,000 in. lb., and will work at angles up to 22 deg. In the larger sizes of Hardy Spicer joints blind bushes carrying the needle rollers are held in place by flat plates secured by two or four setscrews. In the smaller sizes, circlips take the place of these, and this practice has been extended to one size larger in the range than previously.

The Mechanics universal joints were also to be found on many chassis. The needle rollers are in this case housed in stampings bolted individually to faces on the arms on which they are located by radial and circumferential keyways to secure accurate alignment. This construction enables the flange with its rather considerable overhang of the joint to be eliminated, as the housings can be readily removed without exposing the needle rollers.

Rubber-mounted propeller shaft bearing on Reo chassis.

On the Reo chassis, which has American Spicer joints, a rather ingenious construction is employed with the same object in view. Here there are no companion flanges, but the circular blind bushes, housing the needle rollers, fit into semi-circular recesses on the arms with a machined stop lug in each to give end location. The bushes are held in place by D section "U" straps, having shanks passing through holes drilled in the arms and secured by nuts.

Intermediate bearings are employed on many chassis and most of these are designed by the makers themselves, rubber being frequently employed as a cushioning medium. The Laycock Engineering Company offer intermediate bearings carried on two rubber bushes, while on the new 7 ton Bedford, the single intermediate support of the propeller shaft consists of a double row ball bearing in a housing which in its turn is supported in a cylindrical housing by a round section rubber ring, appreciably compressed into the annular space. This gives considerable cushioning action, together with complete fore and aft freedom due to the rolling of the ring.

REAR AXLES

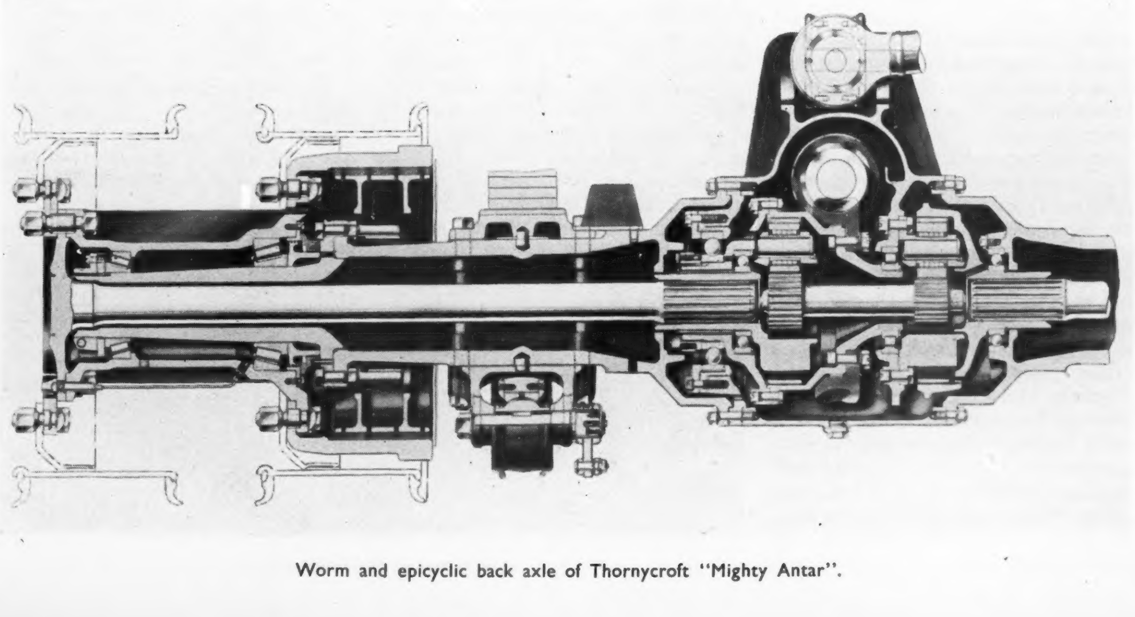
Continued Advance of the Hypoid Bevel Two-Speed Axle

IN vehicles of the medium class the hypoid bevel continues to displace the worm gear, bevel axles working under tyre loads of 8 tons or over in many cases. The very wide adoption of the Eaton two-speed axle has contributed to this and there are several single deck bus chassis of moderate size fitted with it. There are also changes from spiral bevel to the hypoid, an example being the new 7 ton Bedford axle. It is, however, arguable, that for given overall dimensions a spiral bevel might give a longer life under sustained moderately heavy loading than a hypoid on account of the better surface contact conditions and absence of worm-style sliding. What has determined the change over for many manufacturers is the rugged strength of the hypoid pinion tooth, which has practically eliminated failures previously occurring on such vehicles as over-loaded tippers, where the driver uses the reverse or forward gears with extreme violence in an attempt to dislodge his load. There are cases on record of gearing life being increased about six times on vehicles working on civil engineering jobs. The double reduction axle is still employed, principally on very heavy vehicles, or at the other end of the scale on light electrics on which a big reduction is required. A very interesting design of bevel reduction axle is that on the Thornycroft "Antar" tractor, which is intended to handle a maximum gross weight of 100 tons.

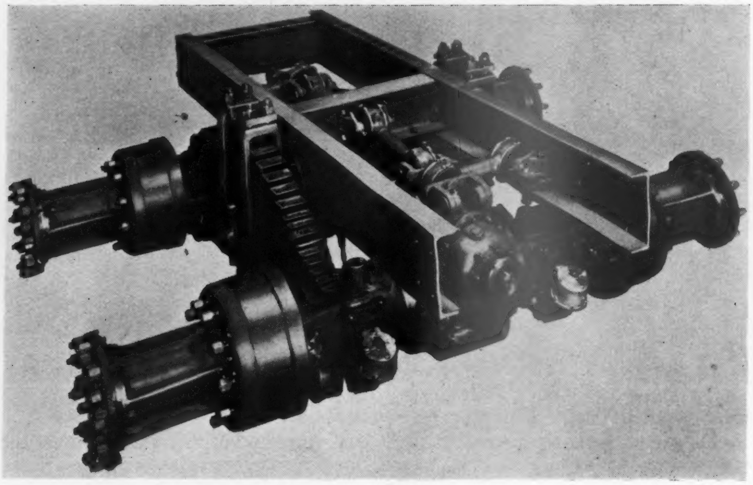
While banjo axle construction is very common on the light and medium weight vehicles, examples of built-up axles still remain. The Fordson commercial vehicles, for example, continue the firm's very old practice of splitting the axle case in the vertical plane, and the larger Morris-Commercial axles are on the same lines. The new Tilling-Stevens hypoid axle has a cast housing with trumpets bolted to it, the differential assembly being carried in the main casing. The new Bedford 7 ton axle continues the firm's practice of employing a one-piece centre casing with pressed-in tubes carrying the differential assembly direct. In bus chassis, excepting for the medium sized single deckers with Eaton axles, the stamped Kirkstall axle pot and worm gear drive are practically universal. Before long even big double-deck buses will probably have hypoid axles or perhaps hypoid axle and epicyclic reduction. Some operators are by no means satisfied with the life they get with existing worm gears. The chief practical difficulty, of course, arises in the case of a double axle bogie, as it is by no means easy to apportion the drive equally between two axles with simple gearing when bevel gearing is employed.

The Eaton Axle Company are now offering a two-speed hypoid geared axle for a tyre load of 16,500 lb. and an input torque of 1,350 lb. ft. The design follows that of the previous smaller axle in having a stout banjo pressing with the differential assembly in it. The hypoid pinion drives a crown wheel bolted to a cylindrical box incorporating the annulus of an epicyclic speed reduction gear, the planet cage of which is attached to the differential box itself. The sun pinion can be slid to engage with internal teeth on the planet cage locking the assembly solid for direct drive. At the other end of its travel, teeth on the muff formed integral with the pinion, engage internal teeth on a plate secured to the differential housing assembly. The sun pinion is then held at rest so that the epicyclic gearing gives a reduction of 1.39 to 1.

Operation of the clutches is normally by a vacuum throw-over mechanism with its control valve connected by a Bowden wire to a knob on the steering column. An interesting feature is the addition of a switch on the axle connected to an adapter on the speedometer cable so that on changing into overdrive, gearing is introduced into the speedometer cable so that the readings remain correct in spite of the altered axle ratio. Just recently an all-electric control mechanism has been introduced as an alternative. This consists of a small electric motor that when energised winds up a torsion spring that shifts the clutches immediately the load is taken off them by



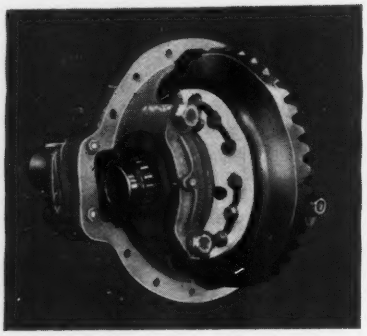
Worm and epicyclic back axle of Thornycroft "Mighty Antar".



Rear bogie of Thornycroft "Mighty Antar" chassis.

the driver releasing the accelerator pedal or withdrawing the engine clutch.

Since the planet pinions of the epicyclic gearing run on plain bushes, lubrication is clearly very important. This is provided for by a drum on the crown wheel assembly picking up oil from the casing and transferring it to a scraper high up in the front of the casing from which it runs in down two alternative channels. One of these serves the opposed Timken bearings of the driving pinion and the other the right-hand differential bearing from which it passes through the differential box to the epicyclic mechanism. Moss Gears are now producing a two-speed axle which in its general design follows the Eaton principles very closely. Vacuum control is employed here also.



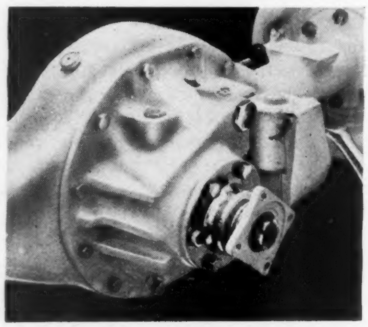
Moss Gear Company's two-speed axle.

The pinion of the new Bedford 7 tonner hypoid gearing is straddle mounted on opposed pre-loaded taper roller bearings with a double row parallel roller bearing at the inner end. In order to give clearance for a large differential box with its stiffening ribs, the centre of the differential gearing is offset considerably to the left-hand side, a practice that is generally followed by makers of hypoid commercial vehicle axles, with the single exception of the Eaton axle. Here, by using a rather large crown wheel they have found space for the straddle bearing in line with the differential box in spite of the fact that there is an extra cylindrical housing between them.

The Bedford axle casing follows the firm's previous practice of a single casting carrying the pinion and the capped seatings for the differential bearings, with axle tubes pressed in and pegged. The caps of the differential bearings have machined pads backing on facings in the main casting. Since the other half of the bearing seating is buried in the casing itself, a very stiff mounting for the differential is thus provided. In spite of this the makers still consider it desirable as an additional precaution to fit a screw adjusted thrust pad behind the crown wheel to take momentary exceptional loads. The new Tilling-Stevens hypoid axle has a casing somewhat similar to the Bedford in regard to the mounting of its bearings. The differential is considerably offset, but the axle tubes take the form of flange trumpets secured by studs.

The Kirkstall Forge hypoid axle is unique in having a stamped banjo in which the capped half seating for the differential bearings are machined, with a separate steel casting spigoted into this, taking both the bearings for the hypoid pinion. Here again the construction is very stiff and any spring in the bearing mountings is prevented. A unique feature of the Kirkstall axle is the provision of a cam-operated pump supplying lubricant to the front pinion bearing and to the gear teeth. In most cases, as, for example, on the Bedford axle, adequate lubrication is considered to be afforded by a channel leading down into an annular space between the two rows of rollers on the forward bearing. The oil is flung into this channel by the motion of this crown wheel and escapes at the front end by a passage drilled underneath. This is, of course, accepted axle practice, but the pump lubrication is possibly to be preferred since it commences to function as soon as the vehicle moves and might possibly supply oil at low speeds when it would not be flung off the teeth of the crown wheel.

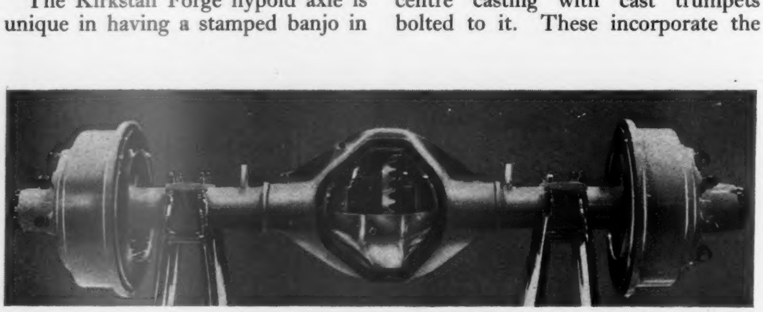
In worm geared axles there were no novel features. Underslung worms



Eaton electrically-controlled two-speed axle.

are employed on all double-deck bus chassis, though one or two single deckers have overhead worm gear.

The most original of the bogie axles shown was that of the enormous Thornycroft "Antar" tractor, which is equipped with 14 × 24 in. twin tyres and is designed for a bogie weight of 36 tons. Each axle is made up of a centre casting with cast trumpets bolted to it. These incorporate the



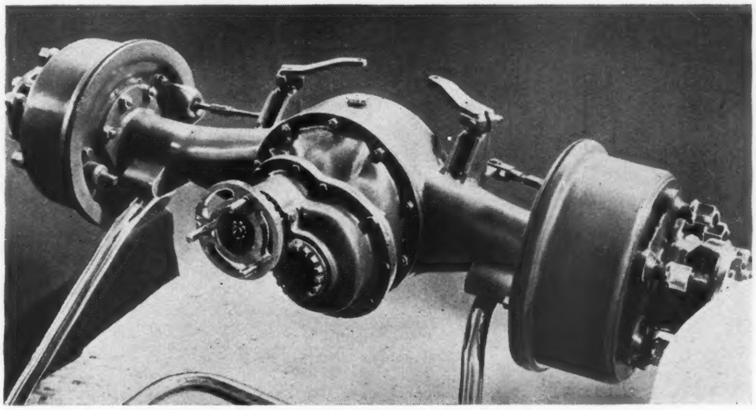
Back axle of Bedford 7-tonner.

spring pads and radius rod anchorages and to their flanged ends steel sleeves are bolted carrying the road wheel bearings. Drive is by an overhead worm gear, the wheel of which is bolted to a rotating box having internal teeth cut in it. Meshing with these internal teeth are the planet pinions of an epicyclic gear, the cage of which is carried by the left-hand axle shaft. The sun wheel is on the short shaft that extends to the right. This has a pinion forming the sun of a second epicyclic gear, planet pinions of which run on studs in a cage fastened to the central axle casing.

The annulus is integral with a stamping, into which the right-hand axle shaft is splined. This arrangement, which is difficult to follow without reference to a drawing, provides at the same time a reduction gear between the worm wheel and the axle shafts and a differential action. It seems to us an excellent way of dealing with the enormous torques in this particular case. The overall reduction is 14.4 to 1. The two axles are connected by a short universally jointed shaft and a third differential can be fitted if required, though for the special overseas operating conditions envisaged, the third differential is not considered desirable.

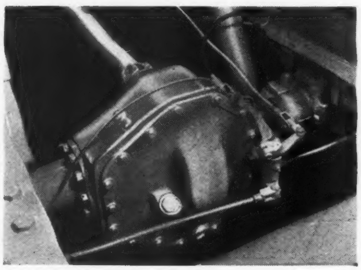
The range of Scammell cross country vehicles include an axle designed many years ago and still in unmodified production, in which epicyclic reduction gears are arranged on each side of a central differential box driven by bevel gearing. Here a reduction of about 5 to 1 is afforded in the epicyclics and a normal bevel differential is fitted. The build-up of the casings is very similar to that on the Kirkstall axle, there being trumpets, including the annular of the epicyclics, bolted to a centre casing, separate diaphragms in which carry the differential box bearings.

Double reduction axles comprising a bevel drive to a countershaft with double differential gearing to a differential box below it, are used on a few



Light double-reduction axle for electric vehicle by Rubery Owen Ltd.

chassis, notably several A.E.C. models. At the other end of the scale a double reduction axle made by Rubery Owen is employed on some of the lighter electric vehicles. This is of banjo form carrying a differential assembly including a first motion shaft connected by spiral gearing to an offset bevel pinion. The purpose of the design,



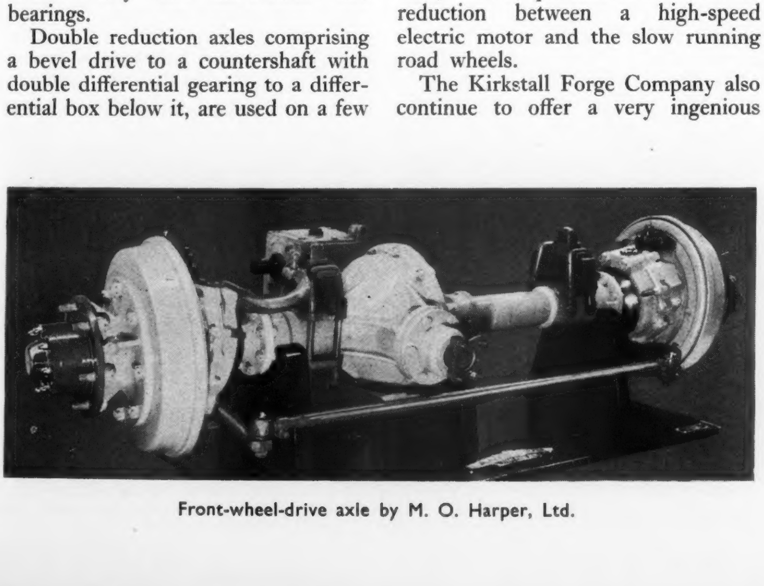
Tilling-Stevens hypoid back axle.

in this instance, is not, of course, to deal with very high torques, as in the case of the Kirkstall and Scammell layouts, but to provide a considerable reduction between a high-speed electric motor and the slow running road wheels.

The Kirkstall Forge Company also continue to offer a very ingenious double reduction axle of their own design, in which a stamped steel axle centre carries a hypoid bevel driven differential box with axle shaft leading out to "epicyclic" gearing in the hubs. The latest design gives a reduction of 3 to 1 in the hub gearing and has two sets of "planet" pinions, allowing an intermediate support for the pins carrying their bearings. This gives a better distribution of load across the considerable total face width of the pinion pairs.

Where a rear axle bogie is employed, the provision for articulation of the axles and their attachment to the frame is still very varied. Probably the boldest and most original design is that, still only to be found on the Scammell cross-country machines, in which a single central axle member complete with worm gear has journalled on its outer ends two rocking gear cases, each carrying a train of five spur gears, providing a reduction of about 2 to 1, and driving a short shaft at each end carrying a road wheel. This system provides a double reduction effect and enormous articulation without any cross twisting or the employment of any universal joints. It is, however, not necessary for normal road work and has the disadvantage that a third differential cannot be fitted, since the two wheels on each side are inseparably geared together. The third differential is generally considered essential on urban bus work, though less desirable or even undesirable on the class of cross-country work for which the Scammell vehicle was designed some twenty years ago.

The bogie arrangement of the Thornycroft "Antar" in which normal through-going axles are, of course, employed, is, if somewhat elaborate, a commendably thorough piece of design. Here the vertical load only is transferred to the axles by enormous



Front-wheel-drive axle by M. O. Harper, Ltd.

inverted semi-elliptic springs rocking on under-mounted bearings and contacting pads machined on the axle arms. These springs take load only, being free to slip sideways and fore and aft on the pads. Longitudinal thrust loads are taken by ball jointed radius rods coming underneath the axles combined with short ball joints high up on top of the worm casings and anchored to a massive frame cross member to take the axle torques in approximately parallel motion style. An interesting point is that lateral location of each axle is by a short cross radius rod anchored to one side frame member and to the top of the worm gear casing. All joints are of the steel ball type, the eyes being in the rods and the balls held on cross pins which do not therefore have to take overhung loads. Rubber enclosure is provided for all the joints and small tension springs are fitted to keep them approximately central so that the wear is uniformly distributed over the surfaces.

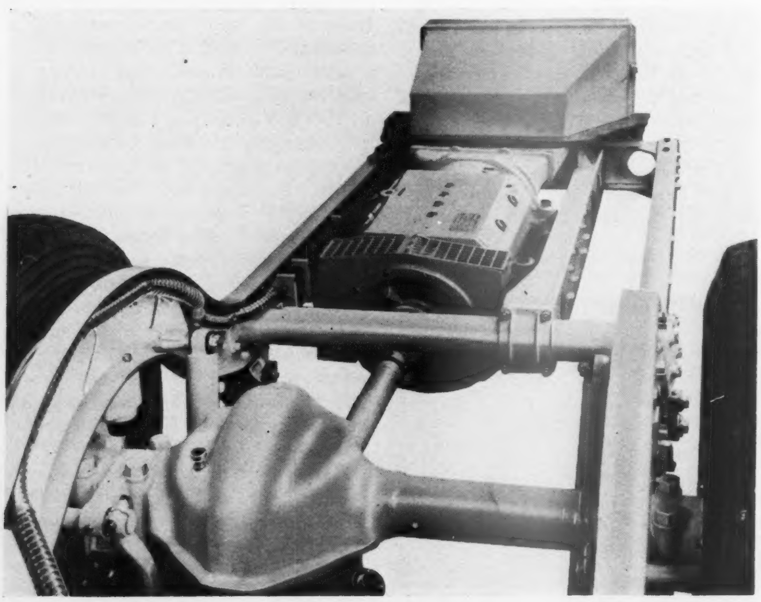
SUSPENSION

No Departures from Orthodox Design

TO the suspension specialist the Commercial Vehicle Show must have been a little disappointing. Ordinary leaf springs in orthodox layouts were everywhere the rule, and although several firms are, it is understood, working on independent front suspensions, there was not a single example of this arrangement to be seen, beyond the suspension of the front wheel of the Scammell mechanical horse. On this vehicle the single front steering wheel is mounted on an arm about 4in. long swinging in bearings in a casing containing a vertical coil spring bearing on a piston connected by a link to a short arm on the shaft inside the casing. A static deflection of about 2¼in. is provided and though the suspension as originally designed embodied an ingenious graduated damping control valve, practical experience has shown that a ⅜in. hole in the piston is all that is necessary. This, no doubt, is due to the fact that the piston is 4in. in diameter and displaces such an enormous quantity of oil that viscosity can be entirely neglected, and the velocity loss gives exactly the damping required.

The Bramber Engineering Company exhibited the Spencer Moulton "Flexitor" which is an independent suspension designed particularly for trailers. In this a sheet metal casing of trough section houses a circular spindle mounted in rubber bonded both to itself and to the casing. To this spindle is splined the short arm, 4in. in some cases and 5½in. long in larger sizes, and to the outer end of which the hub and back plate are secured. A static deflection of about 1½in. is given by the torsional shear of the rubber. Since the rubber also yields slightly in compression under the overhung load, the arm is machined to give the wheel spindle an initial camber of about 1½ deg. This ensures that under working load the wheel does not assume a position of negative camber. The trough-shaped casing can be supplied in flanged form for securing by four bolts to the chassis frame and diagonal members. The system appears to give a simple and very economical suspension, particularly adaptable to low loading trailers where the frame side members can often be bolted direct to the casings.

The makers recommend that the arm should be assembled in a trailing position and with most of the normal sizes of tyres it will be observed that there is a vertical force set up by brake drag some three times as great as the actual ground retardation. In some cases where the brakes are a bit fierce, this may lead to shuddering on brake application, but in the average goods carrying trailer this is of no particular importance.



Rear-mounted driving motor on Sunbeam trolley bus chassis.

Orthodox leaf springs evidence no appreciable change but shot peening of the tension sides of the plates is becoming almost standard practice. Normal steel sections are almost universally employed and there appears to be no particular preference in the treatment of the ends of the leaf spring leaves. A straight cut is to be found just as often as speared ends, while tapered ends are almost unknown. Jonas Woodhead & Sons show springs made of grooved section steel with the object of reducing the weight by removing material on the compression side, the stresses in tension remaining the same as before and the weight of the spring being reduced by about 22 per cent. The section employed has a slight interlocking groove providing lateral location, the raised edges on the inside of the leaf are removed by a reamer after rolling the spring eyes.

Most vehicles have ordinary lubricated shackle pins. Chromium plating is the rule and often with grouped lubrication. Fully automatic lubrication of all chassis points by the Clayton Dewandre R.P. or Tecalemit "Syndromic" lubricators is generally quoted as an extra, although standard on many bus chassis. Clayton Dewandre now produce and offer a 72 point lubricator in addition to their 36 point one.

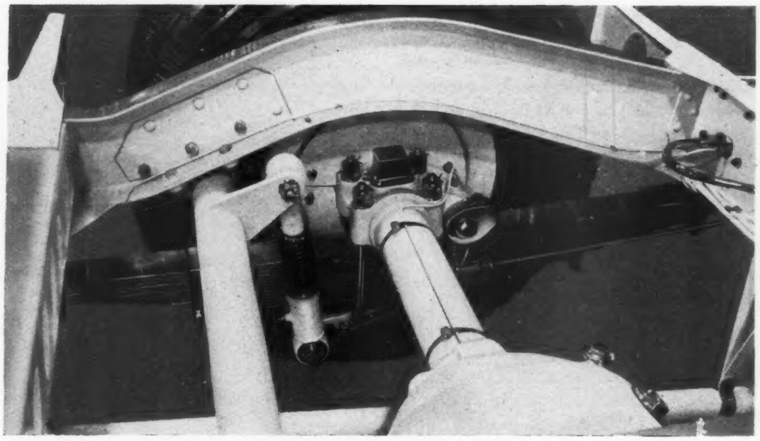
Except for those vehicles based on

private car chassis the rubber bushed spring eye and shackle is not very common. The Metalastik bonded shackle pin, first exhibited by Leyland Motors at the last Show, is increasingly employed, being fitted on Dennis and Guy bus chassis, for example. It is understood that gratifying results have been obtained, one large fleet of vehicles showing a total mileage of 25,000,000 miles with individual mileages of 125,000 miles without any failures. It is very important with these shackle pins to see that they are finally locked in position when the chassis is under normal load, and many different arrangements are to be found for making this operation an easy one.

In the original Leyland Metalastik scheme the parts were assembled and the load applied with the pin free to find its own centre. It was secured by fitting a serrated plate over splines on the pin and in between lugs on the shackle, the whole assembly finally being tightened axially and clamped circumferentially as well.

On the Guy "Arab" chassis the enlarged ends of the shackle pins are simply fitted in capped bosses, the clamping bolts of which are tightened up after the load has been applied. The point, of course, is that these pins, particularly at the shackle end, set up considerable bending stresses in the master leaf of the spring, due to their elastic resistance to angular movement. If, for example, the pins are clamped in the unladen position, there is danger of breaking the top leaf of the spring by the added stresses set up by the movement of the shackle when the load is applied.

Especially on the medium sized vehicles, double rate springs were often to be found. A very good example is the new Bedford 7 tonner, the seven leaf rear springs of which have three stiff supporting leaves underneath. These make contact with the main spring under deflection, with, in addition, a seven leaf helper spring on top which contacts brackets attached to the frame side member under excessive load. The arrangement is completed by stout rubber buffers carried by the main frame, which strike the top leaf of the spring assembly just ahead of centre line. The seven leaves of the helper spring on top of the main master leaf bring the clamping pads very high up, and the makers have wisely arranged the spring U bolts at a sharp angle so that they nearly touch on the spring pads, and are better able to resist fore and aft movement of the main spring under torque loads.



A.E.C. rear anti-roll bar on Crossley chassis.

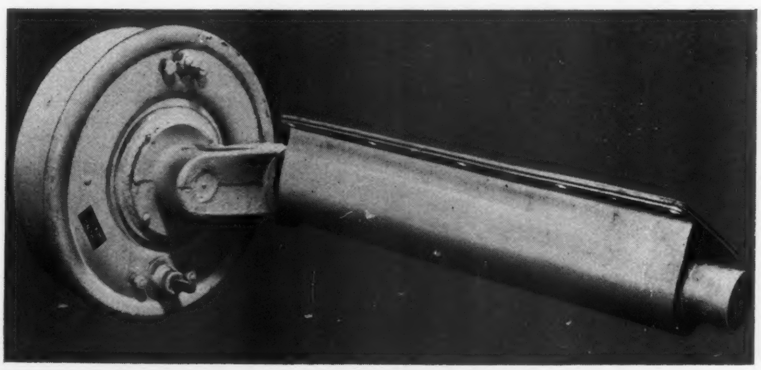
Inclined spring clamping bolts are becoming very common and take various forms. On the Thornycroft "Sturdy" chassis the clamping plate is a substantial steel block with two cross holes into which fit overhanging pins whose ends are tapped to receive the inclined clamping bolts, which are inserted from below through the lugs on the axle.

On the Thornycroft "Antar" axle the enormous inverted springs of the rear bogie are held by forged flat section straps secured by lateral pins passing through lugs on the axle. Welded to the bridges at the top are studs that pass through overhanging lugs of a massive clamping plate the centre portion of which bears down on the spring.

Spring deflections on bus chassis seem to be increasing, there being examples of as much as 6in. static deflection on rear springs and $5\frac{1}{2}$in. on front springs.

A new Sunbeam trolley bus chassis has its driving motor behind the back axle. This arrangement reduces the load on the front axle by about 12 cwt. and is stated to improve considerably the riding of the vehicle. The same result is obtained in the case of the Foden rear engined bus chassis. This has the advantage that since the front axle has its load reduced, it is no longer necessary to fit different size tyres to front and rear wheels, a point of considerable value to operators. Owing to the removal of the large inert mass of the electric motor from the front of the chassis to the rear, it has been found desirable to reduce the stiffness of the front springs considerably.

Although there were no examples of independent front suspension at the Show, Metalastik have developed special coned bushes capable of handling the loads involved in such suspension. The rubber is bonded to the inner and outer bushes and the section is that of a continuous cone with a considerable taper capable of resisting very large end forces as well as radial loads.



Bramber-Spencer-Moulton rubber independent suspension.

The increasing static deflection of bus springs makes the problem of checking roll more difficult. The chassis shown by Crossley Motors, who are now part of the A.E.C. organisation, is fitted with the stabilizer described in connection with the A.E.C. chassis in the last Show. This consists of a fairly stout tube carried in bearings on the frame and

having two arms linked to the ends of the back axle. The special feature consists in allowing a considerable amount of play cushioned by rubber washers in one of the links. The anti-rolling bar, which is very much stiffer than normal, does not therefore come into action until appreciable movement takes place, but it then gives very pronounced support. Stability under extreme conditions is thus assured without the discomfort that would be experienced if the stiff anti-rolling bar was in full action all the time.

BRAKES

Smaller Diameter Drums, with Moulded Bonded Linings

A GENERAL process of detail improvement in brakes was evident and stouter brake-drums, thicker linings and wider shoes are now generally employed. There is, however, no radically novel approach to a problem that, especially in the overseas 'bus market, is a very serious one. There are, for example, no disc brakes exhibited, though one American private car manufacturer has been driven to this admittedly expensive construction in an attempt to overcome the limits set by small rim diameters to the size and surface of the orthodox drum brake. A manufacturer of both Diesel engined passenger vehicles and trolley 'buses produced figures showing the great value of rheostatic braking in reducing the wear of drum brakes. Cases of 250,000 miles without relining were cited.

While the rheostatic brake is frankly a transmission brake, it cannot cause the violent stresses possible with frictional braking. There is a strong case for the employment of some such equivalent on engine-driven vehicles, in the form of an electrically-operated eddy-current brake on the transmission. The B.T.H. concern have, it is said, produced a range of water-cooled eddy-current brakes and they could apparently be fitted to a 'bus without any difficulty. The rather large field current required is within the capacity of the 24-volt dynamos and accumulators now standardised. It is believed that air-cooled eddy-current brakes are widely used in France, special insulation of the field windings is used and the body of the fan-cooled brake is allowed to reach temperatures as high as 700 deg. C., so that considerable amounts of energy can be dissipated.

It is evidently now recognised that the dimensional limits to brake-drums fitted inside 20in. wheels have been reached, or even overstepped. In place of the 17in. by 6in. drum, several firms have been bold enough to go down to 15½in. by 7in. where overall width permits. The new A.E.C. 'bus chassis has brakes of these dimensions, while the Girling Co. have brought out a range of heavy vehicle brakes with drums 15½in. in diameter.

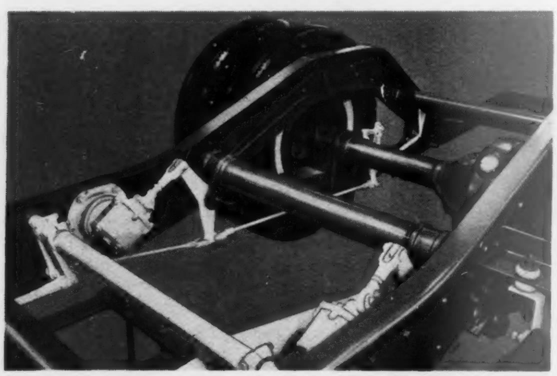
Another general trend is towards the use of moulded, instead of woven, linings to the shoes of heavy vehicles. The Girling Co. use this material, which is, in most sizes, bonded to the shoes instead of being secured by rivets. The trifling amount of extra lining surface thus provided is not the main reason for this practice. Great improvement in drum and lining life results from the absence of rivet holes, which collect abrasive material and score the surfaces.

Many overseas operators prefer to do without brake cover plates, finding that the air circulation inside the drum does more good by direct cooling than harm by the introduction of abrasive dust. Bearing this in mind, the new Girling brakes are mounted on fairly small, very thick, torque plates instead of the customary backplate cover. Light detachable covers can be supplied for those customers who prefer complete enclosure.

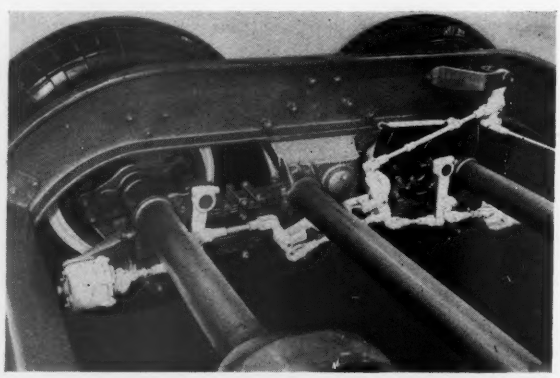
As a general rule those firms who design their own brakes and those who use standard Kirkstall axles employ cam operation of two hinged shoes. The trailing one is forced, by a rigidly-mounted camshaft, to do as much work as the leading shoe. Camshafts, if carried on plain bushes, are usually connected to an R.P. or Tecalemit mechanical lubricator, synthetic rubber seals being fitted to prevent lubricant reaching the brake linings.

Kirkstall still employ the flat-faced cams contacting rounded rubbing plates on the shoes, the cam faces starting life well behind centre line in order to give a big travel without assuming an unfavourable angle. A.E.C. and others employ, with the same object, snail cams working with rollers carried by the shoe tips.

Since a considerable angular movement of the camshaft is required to wear out the ¾in. linings now becoming common adjustment on the rodwork is clearly unpractical. On this account, the scissors type adjuster, formerly standard practice, is being replaced by worm and wheel mechanism inside the brake levers. The Westinghouse Brake Co. are offering such levers as separate components for fitting to customers' brake gear.



Rear brake cylinders on Crossley trolley-bus chassis.



Individual air brake cylinders on Kirkstall rear bogie.

Another solution to the adjustment problem is the R.P. automatic adjuster supplied by Messrs. Clayton-Dewandre. This, it will be remembered, has flat-ended tappets fitted to the shoe tips, these being advanced to take up wear by internal screws connected by a short flexible shaft passing through a clearance hole in the cam component. It is actuated by a finely-graduated ratchet with a worm and wheel worked by the shoe travel.

The Laycock-Neale brake has automatic adjustment by clearance stops of cylindrical ratchet form, which follow up the movement of the shoes, maintaining a definite working stroke. The internally-disposed double-acting air cylinder works the shoe tips through levers whose mid points bear on similar ratchet adjusters that take up any clearance developing between the pistons and the shoe tips. Provision is made, by the use of metals with high coefficients of expansion at appropriate points in the automatic adjustment, to prevent it taking up clearance resulting from a hot drum and thus causing binding when the brake cools off.

Where compressed-air is used on the brakes of the larger vehicles it was customary, at the last Show, to fit individual cylinders operating direct on the last rod connecting the chassis with the axle. It is now becoming increasingly common to mount the cylinders directly on the axle with push-rods thrusting direct on the cam levers. On a Dennis chassis embodying this arrangement, flat steel strips are used for the connection to the hand-brake gear on the chassis. An interesting detail is the reinforcement of the ends of the strips against bending fatigue by thin overlapping spring leaves clamped in the jaws of the end fittings. Individual compressed-air cylinders were shown on the Westinghouse Stand, arranged for direct fitting to Girling wedge-operated brakes and occupying the position occupied by the hydraulic cylinders usually fitted. With the exception of one or two vehicle makers, of which Foden is an example, the design and manufacture of two - leading shoe brakes has been left to the proprietary brake manufacturers.

Westinghouse air cylinders fitted to Girling wedge-expander brake

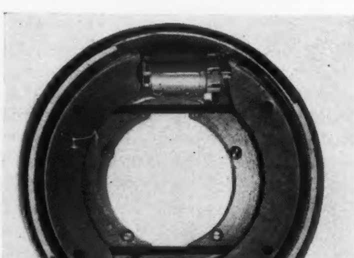
Lockheed are offering a new 2L.S. front brake in which both wheel cylinders are double-ended, with screw adjustment locked by a toothed wheel and spring on the leading pistons. The trailing pistons act as abutments during forward travel but, since they can move away from their stops, 2L.S. braking is available in the reverse direction also.

For the rear brakes of commercial vehicles a new Lockheed brake is available giving 2L.S. operation in the forward direction and floating-cam effect in backward movement. A double-ended wheel cylinder with flat thrust faces bears on the tip of the normal leading shoe and on the tip of a pressed steel carrier on the other side. The lower ends of both members bear on flat-ended adjusting screws that can be turned by a screw-driver through holes in the backplate, individual adjustment being provided. The second shoe is supported by the carrier, the braking load being applied by a central swinging link that permits it to move until its upper end bears on a crossbar fixed to the wheel cylinder, while under rearward movement its lower end abuts on the adjusting screw.

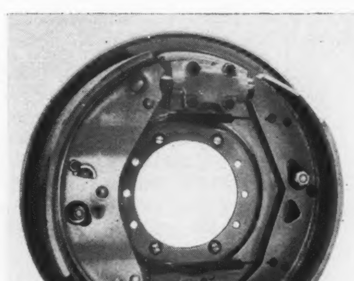
An entirely new range of Girling brakes for medium and heavy commercial vehicles was shown. With a basic drum diameter of 15½in., shoe widths up to 7in. are available. All shoes have double webs, the smaller ones being fabricated and the largest ones Meehanite iron castings. Adjustment is by a very robust version of the usual Girling cone and wedge adjuster, the abutment faces being in this case inclined to obviate concentration of the lining wear at the heel of the shoe. Expanders can be either of the wedge type or of a design embodying a "camshaft" enclosed in an aluminium-bronze housing acting as guide for the cylindrical expanding plungers. Actually a cam is not used, the enlarged end of the shaft having spherical recesses machined in it, in which work two inclined push-rods with ball ends acting as connecting rods between the virtual crankpins of the shaft and the expander plungers.

When 2L.S. in forward direction only is required the leading shoe is normal. The trailing shoe carries between its webs a pair of bell-cranks joined by a ball-ended push-rod as in the original Bendix 2L.S. brake. An abutment is provided on the expander housing for the tips of the trailing shoe, while the expander plunger bears on the tip of the bell-crank which transfers the load, via the push-rod, to the other end of the shoe, which thus becomes a leading one for forward motion. By providing a second abutment face on the expander housing and adding another pair of bell-cranks, the brake can be made 2L.S. in both directions. This is a considerable advantage to the driver when holding a heavy vehicle on the handbrake for a restart on a steep hill.

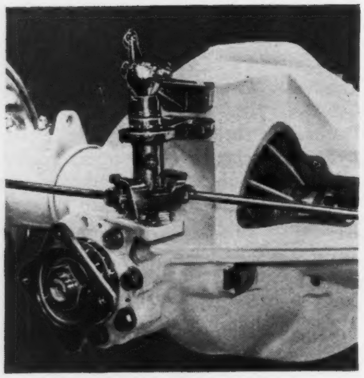
The new Bedford 7-tonner has an interesting brake layout. Here 2L.S. action is not aimed at, but a "floating cam" effect. An expander housing rigidly bolted to the brake support carries a cross-sliding plunger, into a broached rectangular cross-slot in which fits a frame built up of two side plates joined by cross-pins on which run a pair of expander rollers which are actually in contact. These co-operate with the wedge-shaped ends of two expander plungers to thrust apart the top ends of the two shoes. The leading one has a screwed push-rod interposed for adjustment by turning a serrated wheel on it, the trailing shoe bears direct. The two



Lockheed double 2L.S. front brake.



Lockheed 2L.S. rear brake.



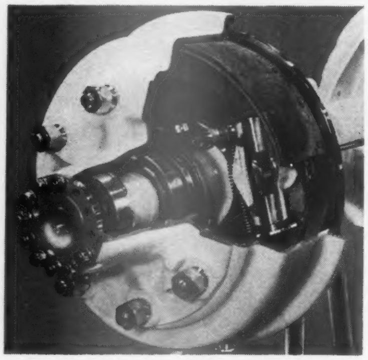
Brake swivel-tree of Bedford 7-ton back axle.

rollers in their frame can slide to compensate for the fact that there is no adjustment on the trailing shoe. The movement is relatively small, since the trailing shoe wears very little. Both shoes are connected to their anchor pins by diagonal links with friction restraint so disposed as to get an even bearing of the lining as it wears without any tendency for heel or toe "grab".

Although the vehicle is fitted with a vacuum servo with hydraulic master cylinder for the front brakes, the rear brakes are connected to the servo by rodwork, as is the handbrake. The mechanism consists of the well-known swivel-tree connected to the brakes by cross-rods. It is operated by two levers, one for the hand operation and the other for the foot, so that failure of one connection does not put the brake totally out of action. In addition one lever is keyed to a spindle splined to the double-armed lever, while the other lever is stamped integral with it. The lateral movement of the swivel-tree for cross-compensation is also limited by stops, while the lever assembly is surrounded by loosely-fitting eyes which would maintain the lever system in operation even if the central spindle were to break. From the practical point of view brake safety under all conceivable failures has been attained, but it is not quite so certain that the arrangement would comply with legal requirements in some countries.

The various vacuum and compressed-air servos are well represented, the Lockheed Co. having recently introduced a simple direct - acting vacuum servo combined with master cylinder for hydraulic brakes for use on the lighter vehicles. On heavier machines their continuous-flow servo with its transmission-driven seven-cylinder radial oil pump building up pressure as called for by the control valve is frequently employed. The same pump is also used in connection with an accumulator system capable of operating door motors, handbrake servos and power steering in addition to the brakes, one of the Daimler 'bus chassis being shown so equipped.

An important modification has been made in the accumulator. This was previously a steel cylinder in which moved a piston having rubber sealing rings, pre-compressed air occupying one side of the piston and the braking fluid the other. This has now been replaced by a rubber extensible bag which contains the air and separates it from the oil, there being of course no appreciable difference of pressure between the inside and the outside. To prevent the rubber being forced through the brake fluid connection when all the oil has been drawn off,



Roller-wedge rear brake on Bedford 7-tonner.

the end of the bag is gripped between two metal washers, the outer one of which seats like a valve in the escape hole.

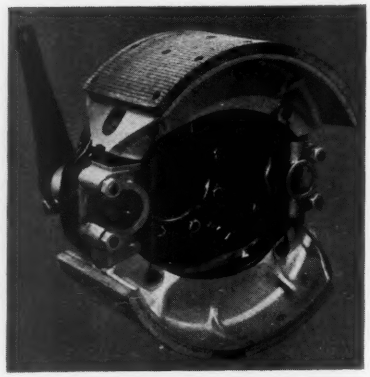
The Foden chassis all employ a

Owing to the continued disruption brought about by the printing dispute, normal publication of this journal is still disturbed.

On this account we have been compelled to combine the September and October numbers in a single issue.

It is possible also that the Annual Extra Number devoted exclusively to the Private Car Show, may be indefinitely delayed.

As planned at present, the Paris Show Report should be appearing in our December issue, which may have to be published in conjunction with the November number.



Girling lever-operated 2L.S. brake.

hydraulic "brake booster" of the firm's own design. This comprises a gear-wheel pump, driven by the engine, supplying oil to the outer side of a Lockheed hydraulic master cylinder. The oil escapes along the hollow piston rod through a valve that can be closed by the pressure of a finger-lever on the brake-pedal shaft. Pressure on the pedal closes this valve and sets up a servo oil pressure in proportion. On the firm's rigid eight-wheeler two master cylinders are mounted one above the other, with their outer sides connected by a large oil passage. Pressure generated as a result of closing the valve on the one master cylinder, is communicated to the other, which gives the same effort minus the direct pedal assistance. The first cylinder is connected to the front wheel brakes and one back axle, while the other one works the brakes on the second back axle.

On those chassis employing compressed-air servos the combined control-valve and reservoir assembly made by both the Westinghouse Brake Co. and Messrs. Clayton-Dewandre, is frequently employed. In this arrangement, unloader-, safety-brake and gearbox servo control valves are combined in a unit attached to one end of the reservoir. This has only to be piped to the compressor and the gearbox and brake lines and connected by rods to the Wilson gear and brake pedals.

Compressors were nearly always of the two-cylinder side-by-side type. In some cases however space will not permit the installation of a unit of this length. The Laycock Engineering Co. showed an ingenious two-cylinder compressor arranged in "Vee" formation to reduce length. The two cylinders are slightly displaced to permit the use of two eccentrics at about 180 deg., giving good balance without the overall length associated with side-by-side cylinders.

Fiat-Mirafiori works for passenger car production.

ITALIAN PRODUCTION

A Survey of the Fiat Factory Layout, Methods and Equipment

THE Fiat organization, which in all gives direct employment to some 63,000 people, is concerned with many different branches of engineering from the manufacture of steel to almost every description of road and rail vehicles and also marine engines, some of very large size. The following notes deal only with the production of Fiat passenger cars, which are all made in the Fiat-Mirafiori factory in Turin.

It is probable that, outside of America, Fiat is the most completely integrated organization engaged in the manufacture of automobiles. Much less use is made of specialist producers than is the general practice in this country. For actual production purposes, Fiat-Mirafiori may be regarded as three separate factories, a foundry, a forge, and a car factory. These notes are chiefly concerned with the car factory.

Regarding the foundry it is not possible to give much detail, since it is at present being reorganized. Therefore, it must suffice to say that it was originally laid out as a fully-mechanized department and it is expected that when the reconstruction and reorganization are completed it will bear comparison with anything of the kind in the world. Nor is it possible to deal at any length with the forge. This department was originally laid down in 1938 and it is still in line with the most advanced modern practice. The equipment includes all types of hammers, upset forging machines and vertical forging machines. It is interesting to note that the heating for several forging machines is effected by induction heating on Tocco equipment. In brief, it may be said that in construction, lay-out and production technique it is still in advance of most European forging departments.

What is generally referred to as the automobile factory occupies about two-thirds of the built-up area of the Mirafiori factory. At present it is laid out for three different models and an output of rather more than 400 vehicles per day is maintained. One of the models, the "1400" came into production about three months ago and the maximum rate has not yet been reached. Actually, the output of this vehicle is stepped up every day, and without any reorganization of lay-out it is confidently expected that the total will eventually exceed 500 units per day for the three models. It will be much higher when certain reconstruction plans have been completed.

The automobile factory

The automobile factory is in the form of a rectangle approximately 750 metres long and 500 metres wide. At one end, the building is extended to form a stores for incoming goods such as batteries and carburettors. This extra bay is divided into three sections, goods receipt, goods inspection and stores for accepted work. Incidentally, in appropriate cases Fiat inspectors carry out inspection in the originating factory so that goods on receipt can be taken direct into stock.

The factory proper comprises a large tool room, a maintenance department, a die shop, a press shop, a heat-treatment department, body assembly lines, body painting plant, a machine shop, engine and transmission assembly lines, upholstery lines and final assembly lines. Generally, the production departments are laid out with the machine lines running transversely and the assembly lines longitudinally in such a manner that the machining operations are finished conveniently in relation to the assembly line. Where this is not possible, provision is made for taking the work to the assembly line by overhead conveyor.

Before certain lines are discussed in detail, general observations may be made regarding the automobile factory in general. Firstly, there is excellent ventilation. In Turin fairly high temperatures are common in summer, while in the winter fairly low temperatures may be experienced and the temperature range is considerably wider than that normally experienced in this country. Nevertheless, because of the excellent heating and ventilation installation, the temperature in the factory is reasonably constant throughout the year.

Mention must also be made of the wide gangways at strategic points in the factory. In the actual machine and assembly lines the spacing is as close as is compatible with easy and efficient working, but there are wide longitudinal and transverse gangways along which even lorry loads of materials can be transported.

In the main, internal transport from one section of the factory to another is effected either by some form of conveyor or by overhead crane, but great use is also made of fork-lift trucks and high-lift platform trucks where their employment is the more suitable. For example, in dealing with the very large tools required for the production of body pressings, large Yale high-lift platform trucks are of great use. Such a truck can carry loads up to $7\frac{1}{2}$ tons and can lift the tools to the most convenient height for insertion in the press.

Press department

Dies for the press department are prepared on the latest types of Ameri-

Forging crankshafts.

a contingency stock of pressings for the body building department.

Body building

There are four sections in the body building department. These are, one for small assemblies and doors, and three body building lines, one for each model. Incidentally, with but few exceptions the electric welding equipment is of Fiat design and manufacture. Although the actual welding equipment is not described, it is worth noting that in addition to having developed a wide range of portable welding guns, Fiat have also developed electronically - controlled spot welders that allow a large number of spot welds to be made simultaneously.

can machines, generally by conventional methods. Attention must however be drawn to the very high standard of finish on all the dies. Press sizes vary from 3 to 2,000 tons capacity, and once again conventional methods are generally employed. However, an interesting and unusual method is used for preparing the sheets from which the roof panel pressing is produced. Two sheets of the correct sizes are welded together in a special flash welding machine. From the welding machine the sheets are removed to a pivoting table and the bead on one side is removed. The table is then pivoted to bring the other side uppermost for the removal of the other bead. Inevitably the welding affects the mechanical properties of the metal adjacent to the welded joint, and to restore the metal to its original condition it is passed through a special rolling machine.

This method of fabrication has been adopted because it allows a complete roof panel to be produced from standard size sheets and greatly eases the supply problems. Excellent results are obtained. In fact, the practice has been so successful that to-day a similar technique is employed for welding together pieces of metal to make other components. Previously, these pieces of metal would have been scrapped.

The general practice in the press department is to arrange that the production run for a main pressing is in the order of 4,000 pieces. This gives an economical run on a press before the tools are changed. It also ensures

Individual parts for the various sub-assemblies are delivered from the press shop to the fixed welding machine section by overhead conveyors. After welding is completed, the sub-assemblies are are delivered to the appropriate body line, also by overhead conveyor. Each of these overhead conveyors carries hooks sequentially numbered. A hook of a specific number is used to transport only one specific part, and when the conveyor is fully loaded, parts are delivered in the correct sequence to the various assembly points.

There are certain differences in the procedures for assembling the body shells for the different models. This arises from the fact that the "1400" has an integral type of body construction while the other models have frames. These notes will deal only with the body assembly line for the "1400" model. As this is the most recently installed line, it is the best for illustrating the body assembly techniques employed by Fiat.

The equipment for body shell assembly comprises jigs for the complete floor assembly, the complete front and the tonneau, a slat conveyor and two body shell assembly jigs. Individual sub-assemblies from the fixed welding machines are delivered in correct sequence to the various stations in the body shell line. The front assembly is carried out on an enclosed circuit floor conveyor with six stations, one for loading and unloading, and five working stations. Actually, 15 parts or sub-assemblies are used at this station.

For the floor assembly 10 different parts are supplied by overhead conveyor to the jigs. A sub-assembly of what may be referred to as the frame is made in one jig and the floor is sub-assembled in another. These parts are then brought together on an enclosed circuit floor conveyor with 10 stations. Pivoting jigs are used so that the work can easily be brought to the most convenient working position. Meanwhile the tonneau assembly is completed on one jig, and in another the moulding is welded to the complete roof panel. Every front, floor and tonneau is checked on a static fixture immediately after the welding is completed.

These various sub-assemblies, after the check has been carried out, are loaded on to a slat conveyor in a definite sequence for delivery to the body shell jigs. This slat conveyor incorporates an automatic cut-out so arranged that if for any reason a part is not lifted off before the end of the run,

A large Gidding and Lewis machine in the die shop.

the conveyor movement is automatically stopped. As soon as the part is removed, the conveyor is automatically started again.

Immediately at the end of the slat conveyor are two body shell jigs, one at either side. Two gangs work on the jigs, so that while one gang is welding in one jig, the other is unloading and loading the second jig. Probably the greatest difficulty in the design of welding jigs for body assembly is to provide the necessary degree of support to ensure that the work produced will be accurate, and at the same time the jig should be of a type that will allow easy loading and unloading and give easy access for the actual welding operations.

This question of combining accuracy with working convenience has been closely studied by the Fiat engineers, and the welding jigs are all remarkably open yet produce accurate results. The jig used for the "1400" body shell is an excellent example of Fiat practice. There are fixed points for locating the floor, the front, and the tonneau, but the side location and clamping elements are arranged to swing clear for loading and unloading. These elements are pivotally fixed to eye-bolts on the base of the jig and are suspended from springs attached to the top.

When the several sub-assemblies are positioned in the jig, the side location and clamping elements are swung forward and are securely fixed by cross braces to give the correct body width and to eliminate any danger of rhomboidal tendency. Longtitudinal bracing is also employed. Practically all the welding is carried with portable welding guns, but provision is also made for using oxy-acetylene plant for welding the door posts to the frame and the roof panel. Incidentally, in pressing the complete roof panel a central strut is left in the windscreen opening to give additional stiffness. This strut is cut out at a later stage. The present standard time for loading, welding and unloading the body shell is only 13 minutes. Soon it will be even lower, since the jigs are being modified to incorporate pneumatic clamping devices.

Immediately beyond the body shell assembly jigs, the body building line is intersected by a transverse gangway, and it is necessary to carry the shell by overhead crane to a second slat conveyor on which the remainder of the body building operations are carried out. On this conveyor the shell is completed ready for painting. Parts such as doors and wings are supplied to this line by overhead conveyor, and the methods employed are conventional. Attention must, however, be drawn to the great thoroughness with which the body is smoothed down to give a really good surface for painting. The standard time for the complete body assembly is 29.00 manhours.

The painting methods do not call for special comment. A normal non-metallic phosphate treatment is carried out, and the body then passes direct into the painting section which is completely separated from the rest of the factory. This section is air-conditioned to give the correct conditions of temperature and humidity, and also to give complete freedom from dust. The standard time for the phosphating and painting treatments is 8.29 manhours. Although Fiat cars are produced in several different colours, all the bodies passing through the painting section in any one day will all be painted the same colour. There are, from time to time, urgent demands for a vehicle of a different colour from that in use, and to meet such demands, the Company maintain a small reserve stock of bodies painted in all the standard colours.

The machine shop

All the production machine lines are arranged transversely across the factory, so that when a component reaches the end of a line it is as near as possible to the appropriate assembly line. Both process grouping and product grouping are employed. For example the whole of the gear cutting machinery is grouped together in one section, while on the other hand, the three cylinder block lines are adjacent to one another.

It is not possible to describe, even briefly, the machining methods for all the important components. However, the methods employed may be illustrated by brief descriptions of the machine lines for the cylinder block, cylinder head, crankshaft and connecting rod for the "1400" engine. This engine is the latest Fiat development and the machine tools employed are almost without exception typical examples of modern American machine tools supplied under Marshall aid.

Before any line is dealt with in detail, it should perhaps be pointed out that components are supplied to the start of the line by overhead crane, but there is no one way of transferring the components from machine to machine. For a component such as a cylinder block, simple roller conveyors are used; for flywheels, gravity conveyors pass the component from machine to machine; while for components such as

The heavy press section.

The finishing line for body assembly.

crankshafts and camshafts, the component is merely taken from the machine and placed on a work carrier which is in such a position that the operator on the next machine can lift it without more than a little movement from his working position. Mention may be made of a fairly complex system of overhead conveyors for transferring components from the machine shop to the centralized heat-treatment department. Incidentally, great use is made of gas carburizing. The real interest of the machine lines lies, however, in the machine tools and the work fixtures that are used, rather than in the methods employed for transferring the work from one operation to the next.

Cylinder-block machining

The number of machines employed to complete the machining on the cylinder block is too great to allow one straight line to be used. Actually, the machines are arranged in three parallel lines. These are so arranged that the block passes along the first, then round a loop on the second line on which it passes back to the starting end to pass round another loop on to the third line, which finishes in a convenient position in relation to the engine assembly line. There is complete flow production.

For the first operation the cylinder block is mounted in a special Cincinnati milling machine. In all, seven cutters are mounted in this machine and the sump face, the joint face, and the main bearing joint faces are all rough and finish machined at one setting. Immediately after these faces have been machined, two accurate location holes are drilled and reamed in the sump face. These holes are location points for subsequent operations. Generally location is by means of spring-loaded plungers in the work fixture which locate in the dowel holes. Following this the ends of the block are milled on a Cincinnati duplex miller and at the same setting two pads are milled on one side. For this operation, two blocks are mounted in one fixture. A further milling operation follows, at which both sides are finish milled.

From these milling operations, the block is transferred to a 4-spindle Ingersoll machine on which the cylinders are rough bored. A somewhat unusual arrangement is used at the next machine, a Natco three-head multi-spindle drilling machine. This machine has two horizontal and one vertical head. A two-station work fixture is used. The block is loaded into the fixture and fixed at the station remote from the loading point. The machine is then operated to drill holes in the joint faces for the bearings and in the ends of the block. At the end of this cycle, the work is brought to the forward station and another series of

Rubbing down section in the painting department.

holes is drilled in each of the end faces. This two-station fixture is necessary since the pitching of the holes in the ends is such as to preclude the possibility of drilling all the holes at one pass. Similar types of machines and fixtures are used at subsequent operations.

The valve guide holes are then drilled, also on a Natco machine, and at the two following operations three-head Natco multi-head machines are used for drilling and reaming operations. At this stage the block is pressure-washed and then given a hydraulic test before any further machining is carried out. Holes that could not be drilled conveniently on the multi-spindle machines are then drilled singly on two radial arm machines. These holes are angularly disposed in relation to the axes of the block and in each case the block is mounted on a work fixture arranged to index about its horizontal axis. Stops on the structure carrying the fixture, locate in slots in the fixture to give quick and accurate correct angular disposition for every hole. Further drilling and tapping operations are then carried out on three-head multi-spindle Natco machines. On both machines two-station work fixtures of the type previously described are used.

At this stage the block is again pressure washed. The bearing caps are then fitted and several important operations follow. First, the main bearings and the camshaft holes are rough bored simultaneously, and at the next operation these elements are finish machined.

A special Natco twin-head horizontal drilling machine is used for the next operation. On this machine the seatings for the oil level gauge and the oil pump are rough and finish machined, the seating for the ignition distributor is rough and semi-finish machined, and in addition two holes for fixing the pump and two for securing the ignition distributor are also drilled. Mounted on the pedestal of this machine are two slide-ways on which the two tool heads slide. A special work-holding fixture is mounted in the centre of the bed between the two tool heads.

This work-holding fixture consists of a frame carrying a vertically arranged table that is arranged to swivel about a horizontal axis. The table holds three blocks at once and is fitted with a six-station indexing arrangement, five working stations and one unloading station. A conveniently situated and easily operated hand wheels actuates the clamping devices. The two spindles in the heads are driven and fed mechanically by separate motors, while their lateral movements are controlled through electro-hydraulic devices.

This machine is fully automatic in operation and the operator has only to load and lock the work in position and press the start button. Loading and locking of the work carrying fixture are effected during the actual working cycle and therefore do not form an idle-time period in the operating cycle. Conveniently arranged electrical controls by push buttons mounted on a panel within easy reach of the operator, allow off-cycle movements to be carried out, thus facilitating setting up. Suitably arranged safety devices make this machine suitable for operation by semi-skilled labour.

One of the paint spraying booths

Incidentally, the loading height for this machine is considerably higher than that of other machines in the line. Consequently, the conveyor height is appreciably below the loading height. To simplify loading and unloading and to eliminate operational fatigue as far as possible, a short length of the roller conveyor on each side of the machine is fitted with a special auxiliary system of compressed air lift. This lift brings the appropriate portion of the main track into line with an auxiliary roller slide-way at the correct height for easy loading. The standard output from this machine is 25 blocks per hour.

Further drilling operations on a radial arm machine with an indexing fixture and tapping operations on a Natco three-head multi-tapper are then carried out. At this stage the block is once again pressure washed. Following this there are three milling operations. At the first all the main bearings, with the exception of one face, are finished to width. At the second, the face left at the previous operation is finished, and at the third, the oil grooves are machined. At this stage the cylinder bores are finish machined on a two-spindle Ingersoll machine. At the first pass, Nos. 1 and 3 cylinders are bored, the head then returns to the off-position and the work fixture is automatically indexed to bring Nos. 2 and 4

Part of the cylinder head line

Engine assembly line for model '1400'

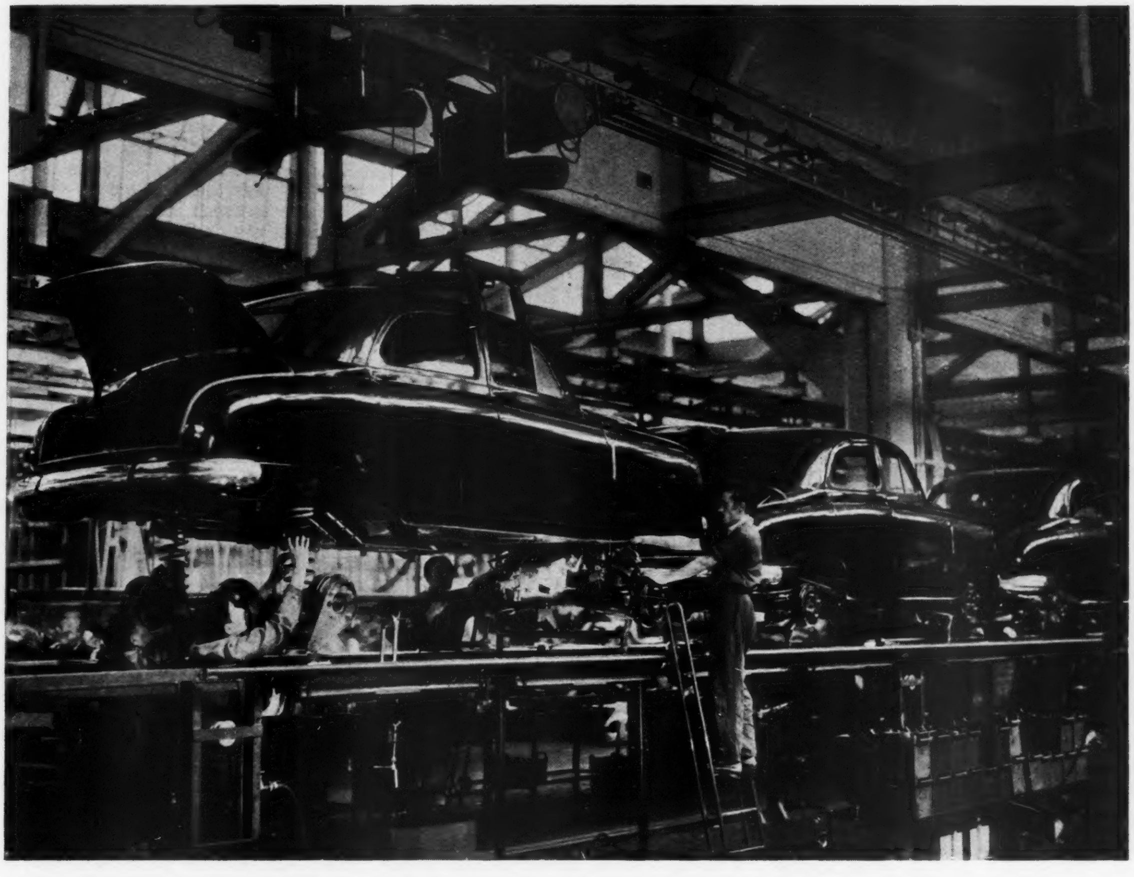
cylinders into the boring position.

After another, and final, hydraulic test, one end main bearing is counter-bored, after which further tapping is carried out on a Natco multi-tapper. All the bores are then carefully checked with Solex gauges to ensure that the bores conform to the prescribed dimensional limits and that the required high degree of accuracy as regards ovality and taper is maintained. A light finishing milling cut is then taken on the sump and joint faces and all relevant surfaces are de-burred by hand before the pre-finished liners are inserted. The block is then given another pressure wash, followed by a complete check before it is transferred to the assembly section. The actual total machining time on the cylinder is between 42 and 43 minutes.

Cylinder head machining

Aluminium cylinder heads are used for the engines for all three models. So far as the machining for the cylinder head of the "1400" engine is con-

Body trim department



Assembling body to power and transmission units for model '1400'

cerned, the most outstanding point is the number of machines employed. This arises from the use of multi-station multi-spindle machines. There is no point in following through the detailed sequence of operations, but a brief description of some of the more unusual features of this line is not without interest.

For example, an unusual set-up is employed on the first machine in the line. This is an Ingersoll vertical milling machine, with twin heads and a circular indexing table. There are four work fixtures on the table, but each one is designed for a different operation. In order, the fixtures allow the top face, the joint face and both sides to be milled Obviously the fixtures are all designed to give a constant height in relation to the cutters. Two cutters are mounted on this machine and while the sides are rough and finish milled at one setting, the joint and top faces are rough and semi-finish machined. These faces could, of course, be finish machined at this setting, but it is considered advisable to leave a small allowance for a light finishing cut, in case of accidental damage during the machining sequence. This unconventional arrangement for machining four different faces on one machine is very economical.

It is perhaps through the use of Natco three-head multi-spindle machines for drilling, reaming and tapping operations, that the machining can be completed on so few machines. One of these Natco machines is used for drilling holes in one of the faces and in the sides. It has one vertical and two angular heads. The angular heads are for drilling spark plug holes and other holes at an angle to the axis of the block. The machine has a circular indexing table with two work fixtures. There are three working stations in the cycle. A similar work table arrangement is used on the next Natco machine, on which the other face and the ends of the head are drilled. This second machine has two horizontal and one vertical multi-spindle heads.

A three-head Natco multi-spindle machine is used for the necessary tapping on the cylinder head. This has one vertical and two horizontal heads, which are at right angles. Two work-holding fixtures, one on top of the other, are mounted on the machine table. The lower of these fixtures is mounted at an angle to allow the spark plug holes to be tapped from a horizontal head. The holes to take the valve guides are also rough bored, semi-finish and finish reamed at one setting on a multi-head machine.

When the machining on the head is complete, except for the light finishing cuts on the faces, a hydraulic test is carried out. The casting is then heated to 250 deg C to allow the valve seat inserts to be placed in position. This gives a shrink fit, but to give greater security, the inserts are locked in position by means of a special rolling tool. The valve guide bores are then finish reamed to size on a single spindle machine, following which the valve seat is form milled. The form millers have floating mountings on the machine spindles. A correctly fitting pilot plug is inserted in each valve guide and each form milling tool has a hollow centre to pass over the pilot plug to give accurate location in relation to the valve guide bore. The total tolerance on concentricity is 0.001mm. To complete the head, a light milling cut is taken across both the joint face and the top face. Every head is completely inspected before it is transferred to the assembly department.

Crankshaft machining

As is the normal practice in machining a crankshaft, the first operation is to face the ends to length. There is, however, a difference between the Fiat practice and the normal English practice in that two shafts are milled to length at one setting on a duplex milling machine. The ends are then

centred on a Sundstrand double-end centring machine, following which the shaft is mounted in centres in a milling machine, and location surfaces for subsequent surfaces are machined on two webs.

At this stage the shaft is transferred to a Le Blond line bearing machine on which the main journals and all other diameters struck about the shaft axis and the webs adjacent to the main journals are machined. This is the most advanced American machine for this class of work. It is essentially a multi-tool lathe designed for high rates of output. Not only is it designed to give a high rate of metal removal, but in addition, loading and unloading times are cut to a minimum by the provision of limit switches which ensure that the machine always stops with the chuck in the correct position for loading.

This machine has a relatively complex automatic cycle. When the shaft is locked in position and the start button pressed, the tools advance towards the cut at fast traverse. At a pre-set position the feed is automatically slowed to the feed rate for rough turning and is later slowed further to give the correct speed for finish forming. Finally, the tools are retracted at fast traverse and the machine stops with the chuck in the correct position for loading. In all, eight diameters are turned simultaneously on this machine.

After the operations on the Le Blond line bearing machine, the shaft is tested for straightness. The main journals are then rough ground on a Landis machine. From the grinder the shaft is transferred to a second Le Blond machine, in this case an automatic crankshaft lathe. This machine carries two shafts at a time, one above the other. The tooling is so arranged that the webs are faced on the upper shaft and the crankpins are turned on the lower shaft. The shafts are clamped hydraulically in chucks, and interlocks prevent the starting of the machine cycle until the clamping is properly effected. This machine also has a completely automatic machine cycle. High output rates and a close degree of accuracy are obtained with these Le Blond machines. It is no exaggeration to say that from the point of view of output, the two Le Blond machines are the most important in the line.

After the crankpins and webs have been machined, the shaft is again tested for straightness. Then on three special machines the several long oil holes are drilled. These are dual-head machines. Each head has an independent and completely automatic cycle with retraction of the head to clear the drill at periodic intervals.

The shaft ends are then finished on two capstan lathes. From this stage on, the operations generally are carried out on grinding machines. To begin, the flywheel end of the shaft is finish ground on a Landis machine on which two formed wheels are mounted. The flange to take the flywheel is then drilled and tapped before the crankpins are finish ground on a Landis crankpin grinder. On this machine, the chucks for carrying the shaft incorporate special means for rapid and accurate indexing to bring the various pins into the grinding position. An automatic sizing device is also incorporated in the design.

Two further grinding operations are carried out on Landis machines. At the first, the centre bearing webs are accurately ground to give location faces for assembly. At the second, the other end of the shaft is accurately ground to length. The next important operation is balancing on a Dynetric balancing machine. After the shaft has been balanced, the machining is completed by a finishing operation of all journals and pins. This is carried out on the latest type of Norton machine in which the paper is stationary while the shaft revolves. A very high degree of surface finish is obtained. Finally, the shaft is fully examined. It is interesting to note that Sheffield "Precissionaire" equipment, which works on the same principle as Solex equipment, is used for checking external diameters.

Connecting-rod machining

Although these notes are concerned only with the methods used in the production of components for "1400" engines, reference must be made to the fact that certain machines in the connecting rod line have an output capacity considerably in excess of the present requirements for this one type of engine. Therefore in order that maximum effective use may be made of the machines, in certain cases connecting rods for another type of engine are machined simultaneously with rods for the "1400" engine. This does not entail extra transport, since the machines are so arranged that those dealing with two different rods can feed both lines with equal facility.

At the first machine in the line, a Blanchard surface grinder, the side faces are ground to width. On this machine both "1400" and "500" connecting rods are ground simultaneously. When both sides have been ground the rod is transferred to a Natco 6-spindle machine on which the

Final assembly lines for '500' '1100' and '1400' cars

gudgeon pin hole is bored. This machine has a four-station work-holding fixture arranged to take two rods at each station. There are three working stations and a loading and unloading station. At the first working station the holes in both rods are core drilled, semi-finish reamed at the second, and finish reamed at the third.

Surface broaching on a two-slide Cincinnati machine is employed at the next operation. At the first slide the faces for the bearing cap nuts are machined and the rod is split. At the second slide, the rod is mounted in one fixture and the cap in another, and two circular broaches are used to rough machine the half bores.

At the next operation both "1400" and "500" connecting rods are machined simultaneously on a Greenlees multi-spindle drilling and tapping machine. Four rods and four caps for each model are mounted in a circular work fixture that is arranged to index so that the necessary drilling and tapping can be effected at a single setting. As soon as this operation is completed, the cap is assembled to the rod.

From the Greenlees machine the rods are transferred to a Blanchard surface grinder to be finish ground to width. Once again both "1400" and "500" rods are dealt with simultaneously. At the next operation the big end bore is semi-finished to size on a fine boring machine. A double end machine is used. It is tooled for machining two "1400" rods at one end and two "500" rods at the other. At this stage the gudgeon pin bush is fitted and the next important operation is to finish both holes to size on a Heald Borematic. Despite the degree of accuracy and surface finish that can be maintained on a Borematic machine, it is considered advisable to generate even greater accuracy and better finish on the big end more by honing it on a Micromatic machine. Finally, the rod is weighed and given a complete dimensional check.

Engine assembly

Most of the engine components are delivered direct from the production line to the assembly line, but before the cylinder block reaches the line, the studs are inserted, the block is painted and is finally given three pressure washings in different media to ensure that all foreign matter is removed.

Engine assembly is carried out on a chain conveyor with stands that carry the engine at a convenient height. In themselves the actual assembly functions do not call for comment, since they must follow a certain prescribed sequence. There are three outstanding features of this line. The first, and this applies to all the assembly lines, is the general air of neatness and cleanliness. Secondly, there is the particularly neat and convenient arrangement of stock banks. There is a daily issue of materials to the line and the stocks are so arranged that all the appropriate components are within reach of the operator at any specific station. Thirdly, reference must be made to the scrupulous care taken to ensure that parts such as crankshafts and bearings are absolutely clean before they are assembled into the engine. For example, thin wall bearings are stocked in an oil bath in a covered container, from which they are removed only when wanted. In the case of the crankshaft, two pressure washings are carried out immediately before the shaft is assembled into position.

From the assembly line the engine is taken by overhead crane to the engine test house. At present every engine is tested for three hours, and readings are taken of power output at various speeds and of petrol consumption. This testing is a lengthy and expensive operation. It is probable that in the near future the test period will be reduced.

After test, the gear box and clutch are assembled to the engine and the complete unit is transferred to another assembly conveyor where it meets the front and rear axle assemblies. This conveyor carries correctly spaced cradles for taking the axle assemblies. In eight stations along it, the assembly together of the power and transmission units is completed. The conveyor runs at about 8ft above floor level until the assemblies are completed. It then dips to floor level and passes under another conveyor, on to which bodies from the trim department are transferred by a high speed overhead crane that runs on an enclosed circuit. This length of conveyor carries ten bodies.

Beyond the conveyor for the bodies from the trim department, the conveyor carrying the power and transmission units rises to its original height ready for a body to be dropped into position. Actually, the high speed overhead crane deposits one body at one end of the short conveyor, continues on its circuit and picks up the leading body and carries it to meet the power and transmission unit.

Once the body and the power and transmission units have become a single unit, they proceed together for ten stations along the overhead conveyor. Practically all the work carried out at these stations is on the underside of the car. For example, the silencer, the brake system and the electrical cables are fitted. To give adequate lighting on the underside of the car, strip lights, shining up, are fitted in troughs on the conveyor frame.

By the time the car reaches the end of this elevated conveyor, the wheels and tyres are fitted. The conveyor then drops to floor level for the final assembly functions, which are those normally carried out on the mounting lines in English automobile factories. At the end of the line the car is given a complete visual examination to ensure that all the work has been completed satisfactorily.

Finally, the car is run for 50km on the factory test track. On this test run the car is checked through all the gears. In addition, the track has been designed to give adequate test of the suspension system. For example, part of the track has poor surfaces, including pave, typical of those that may be encountered in normal driving throughout Europe.

Although this survey has dealt mainly with the methods employed for "1400" cars, and even then only with a relatively small number of components, it may be worth while to summarize the general impressions gathered while the data on which the survey is based were being collected.

(1) The extremely compact lay-out and the way in which full use is made of floor area.

(2) The manner in which the various component production lines have been laid out so that as far as possible the machining line for a specific component finishes at a convenient position in relation to the appropriate assembly line.

(3) The very wide use made of fixed mechanical conveyors of all descriptions, and more particularly, the wide use of overhead conveyors for the transfer of materials from one department to another. In general, other methods of transfer are employed only when the weights are too great for a normal mechanical conveyor.

(4) The high efficiency of the machine tools, obtained through Marshall aid.

(5) The manner in which continuous work flow is maintained on the various machine lines so that work in progress is kept to a low figure.

(6) The great cleanliness of the factory, and more particularly of the assembly lines.

Aluminium in Road Transport

THE papers read at the Symposium on Aluminium in Road Transport held early this year, have now been issued in a bound volume obtainable from the Aluminium Development Association, 33, Grosvenor Street, London, W.1. It may be useful to recall that the following papers were read: "Review and Preview," "Aluminium in Commercial Vehicles," "Aluminium in Public Service Vehicles," "Aluminium in the Private Car," "Properties and Fabrication of Aluminium," "Aluminium Vehicle Maintenance," and "Aluminium from the Users' Angle." (1917)

Conference on Production

ON November 15 and 16, the Utilization Section of the Institution of Electrical Engineers is holding a Conference on "Electricity as an Aid to Productivity." It is intended to make available to industry the latest information concerning the contribution that factory electrification can make towards increased production. It will consist of a series of lectures, each of which will be followed by a general discussion. (1909)

HIGH-FREQUENCY HARDENING

A New Birlec Plant Installed at the Humber Works

IN accordance with their policy of designing and building specialized production high-frequency equipment for the automobile industry, Birlec Ltd., Tyburn Road, Erdington, Birmingham 24, have recently installed a unique and successful plant at the Coventry Works of Humber Ltd. It is designed to give selective surface hardening on fifteen different components, the largest requirements being for Hillman Minx gearbox selector rods and overhead rocker valve shafts for the Sunbeam Talbot engine. In addition, the plant will harden selected portions of seven other shafts and spindles of varying diameters and lengths. The case depth produced averages 0.030in, but it can be varied by simple adjustment.

On all these components only small sections of the length are subject to wear. For example, the selector rods are notched to take a spring-loaded locating ball, and hardening is necessary only over and around the notches and over two short sliding bearing surfaces near the shaft ends. The rocker shafts need to be hard only where there is contact with the rockers. It will be appreciated that high-frequency methods are the best available for this class of work, since by no other means could such selective hardening patterns be so easily obtained on a production basis.

Previously the components were case-hardened by conventional methods over their whole lengths after carburizing. Now all the components are made from direct hardening steel and the conventional carburizing and hardening operations are eliminated. The advantages obtained through selective induction hardening in comparison with previous methods are:—

(1) greatly reduced distortion.
(2) greater toughness.
(3) increased output for a given running cost.
(4) economy in floor space, the equipment occupies an overall floor area of 12ft × 12ft.
(5) clean and easy operation with unskilled labour.
(6) guaranteed repetitive results.

An hourly output of 240 selector rods and 120 rocker shafts can easily be maintained.

Basically the plant comprises two main sections, a thermionic valve oscillator as power supply and a work handling unit. The power unit has an output of 20 kW at 350 kc/s, fed from an automatically regulated 400 volts, three phase, 50 cycles supply which is stepped-up to 10 kV and rectified. Provision is made for water cooling the valves, the tank coil and the workhead transformer. Re-circulated filtered and softened water is used, and full protection against failure of the water supply and against overloading is incorporated in the design. Comprehensive metering of all circuits is provided by conveniently grouped instruments, controls and pilot lights.

Special Birlec unit for hardening shafts.

Birlec Ltd. have specially designed the handling unit to comply with customer's requirements. Basically it comprises two vee blocks, inclined at a few degrees from the vertical and accurately lined up above and below the inductor and water quench ring, with suitable mechanism for progressing the shafts and constant and controlled speed through the heating and quenching process. An adjustable finger projects just above the inductor when the machine is in the rest position. The shaft is loaded vertically by hand into the upper vee block with its lower end supported by the finger. This operation is shown in the accompanying illustration.

When the shaft is loaded into the machine, depression of a pedal sets the traverse mechanism in motion. This is an electrically driven constant-speed device that carries the finger and shaft down in line with the vee blocks until the appropriate lengths of the shaft have passed through the inductor and quench. The mechanism then automatically reverses and rapidly returns the hardened shaft to the rest position for manual unloading. This completes the cycle.

A manual speed control is located alongside the loading table. It is operated in conjunction with a speed indicator calibrated in inches traverse per second. The traverse is thus instantly adjustable to suit various shaft diameters and case depths. The workhead is a particularly interesting feature of the equipment. It is specially constructed for easy and rapid inter-change of inductors to suit different shaft diameters.

A standard high - frequency unit is located immediately below the work table surface. Water cooling is provided to the inductor, and a hand-operated valve conveniently positioned to the right of the work table controls the supply. Interchange of inductors can be effected in approximately five minutes. Immediately below the inductor there is a quench ring designed to direct a powerful, uniform sheet of water on to the heated surface. This ensures efficient quenching. The lower vee block, located below the quench ring, in addition to giving continuous accurate location of the work during the passage through the inductor, also supports the work during its travel through the quench ring.

The traverse mechanism is simple but ingenious in construction. Speed variation is obtained through an infinitely variable friction gear. Reversing is effected through magnetic clutches which couple the drive to one or other of two layshafts rotating continuously in opposite directions. Rapid reversal of the direction of travel is effected by operation of an electrical limit switch.

The different conditions for different classes of work are obtained through a series of quickly interchangeable cam plates which are attached to the traverse assembly. These cams operate electrical limit switches which control high-frequency power, reversing, and the stopping of the mechanism at the end of its return travel. Cam changes can be effected in less than a minute.

THE DK CHASSIS

A Danish-built Vehicle with Front-wheel Drive

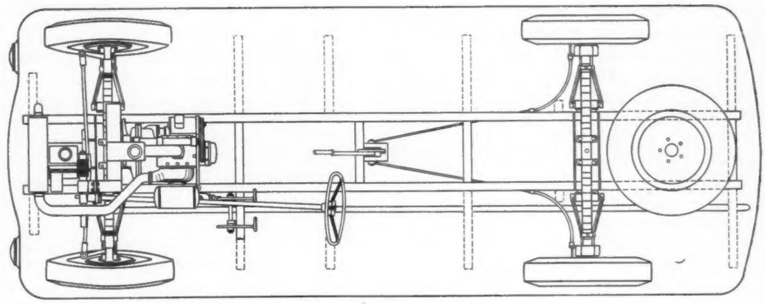
THE accompanying illustrations show a Danish chassis exhibited at the Danish Automobile Exhibition early this year and manufactured by Bohnstedt Petersen A/S., Copenhagen. It is available either as a 5-6 passenger private car or as a delivery van. Two alternative engines can be accommodated in the chassis, model A1 having a D.K.W. 600 c.c. twin-cylinder two-stroke engine developing 22 b.h.p. at 4,000 r.p.m. Power transmission is through a multi-plate wet clutch and a three-speed and reverse gearbox. Alternatively model A2 has an I.L.O. 750 c.c. 2×2 cylinder uniflow two-stroke engine in unit with a Komet single dry plate clutch and a four-speed and reverse gearbox having synchromesh on third and fourth speeds. This engine gives a maximum torque of 49·2 lb ft over the speed range of 1,500 to 2,000 r.p.m.

From the differential assembly the drive is taken to the front wheels through open shafts having Layrub flexible couplings at the differential end and Hardy Spicer universal joints at the stub axles. These are carried in SKF ball bearings and it is of interest to note that the hub bearings are interchangeable between front and rear wheels. Axial location of the wheel is provided by the outer bearing, the inner bearing being spring-loaded against a shoulder on the stub axle behind the universal joint fork.

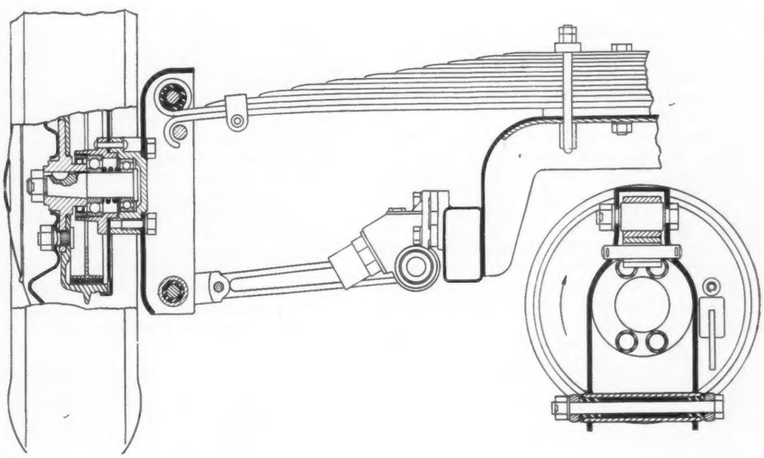
The front hub is located by means of a taper and two Woodruff keys. Plain swivel bushes are provided, the inclination of the swivel centre-line being 8 deg. from the vertical, while the camber angle of 4 deg. appears to be unusually high. The suspension, which is, of course, independent, is by means of an upper transverse leaf spring with wishbones below.

The front spring has plain bushes in the eyes and the third leaf is upturned to encircle a pin located in an extension of the upper swivel pin to provide a safeguard against breakage of the main leaf. Harrisflex bushes are used for the outer ends of the wishbones, while the inner ends are carried by the spindles of the Boge hydraulic dampers mounted on the frame side members. Rack and pinion steering is embodied with Harrisflex bushes at the ends of the unequal length track rods.

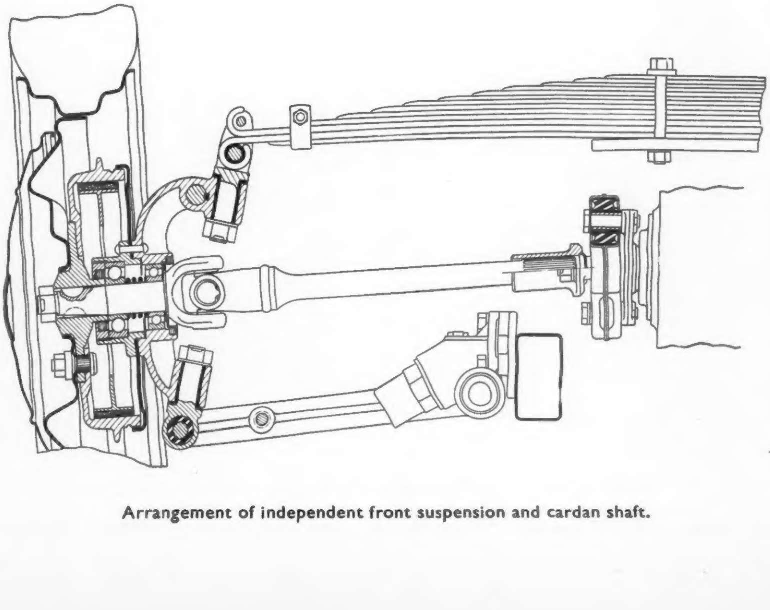
The rear suspension is similar to



Layout of DK chassis.



Arrangement of independent rear suspension.



Arrangement of independent front suspension and cardan shaft.

the front, namely by means of a transverse spring and wishbones. In this case, however, Harrisflex bushes are also used in the spring eyes and the bottom blade of the spring encircles a pin carried in the pressed stub axle carrier. The rear hubs are mounted on the stub axles by means of a taper and single Woodruff key. End location of the stub axle is again by means of the outer ball bearing, outward thrust being transmitted from the inner race of the inner bearing through the medium of a coil spring.

Lockheed hydraulic brakes 9in. in diameter by $1\frac{1}{2}$in wide, have $\frac{7}{8}$in wheel cylinders and a $\frac{7}{8}$in master cylinder. The hand brake operates the rear shoes by means of flexible cables. Sankey steel wheels are fitted with $5\cdot50 \times 16$ tyres. The frame is made up of box-section members, the side members being parallel in plan view and straight in elevation. There are five straight box-section cross members with, in addition, channel section bridge members front and rear to provide seatings for the transverse springs.

Many British-made components are embodied in addition to those already mentioned. Much of the electrical equipment is of Lucas manufacture and the instruments are supplied by S. Smith and Sons (England), Ltd. The all-steel body has Wilmot-Breeden fittings and bumpers. The chassis dimensions are: wheelbase 2,600 mm; track (front) 1,210 mm, (rear) 1,300 mm; minimum ground clearance 220 mm. The fully laden weight of the private car is stated to be 1,250 kg and of the delivery van 1,750 kg.

RECENT PUBLICATIONS

Estimating and Planning for Engineering Production

By P. S. Houghton, A.M.I.Mech.E.
London: BLACKIE & SON, LTD., 66, Chandos Place, W.C.2. 1950. $5\frac{3}{4} \times 8\frac{1}{2}$. 366 pp. Price 25s.

Accurate estimating is vital to production, in fact production cannot begin at all until a job has been estimated, and if this is done incorrectly trouble must follow. The estimator has to have a reasonably wide knowledge of every phase of manufacture of the products with which he is concerned, from the incoming raw materials to the finished weight of the job. He needs to know the machining speeds of every type of material to be used on the job, the type of materials to be employed, the types of machines to be used for production, and he must know something of process planning. It would be useless for him to estimate a job employing incorrect machines or equipment that was not available, or a sequence of machining that was not adaptable to the works concerned.

Quite correctly, the author opens with a full description of the slide rule, for surely this is the most used tool of the estimator, and he then goes on to graphical representation, in which he works up to the value of machine charts. The next chapters cover the fundamentals of his business, material requirements, other charges such as transport, outside erection, etc., and finally process planning is dealt with briefly.

Most of the book deals with machine and cutting speeds and data. The factors governing machining speeds are very carefully covered and numerous tables giving the cutting speeds for steel, cast iron and non-ferrous metals are included. Tables are also provided for all details concerned with alloy steels for bars, billets, forgings, stampings, etc., giving the composition, how supplied (black, bright, etc.), properties and constant. This is the information that an estimator must have at his disposal.

Following the estimation of machining speeds, there naturally follows a chapter on control and horse-power requirements and this includes a chart giving the speed and power requirements for a known chip-dimension set out on a bilogarithmic basis. Further chapters deal with the estimation of machining times, estimation of cutting speeds, indirect expenses, pricing and a chapter devoted to examples of estimating must be extremely valuable to the reader.

The book abounds in graphs, charts and tables, and is probably one of the most comprehensive volumes obtainable on estimating and planning. There are, for example, some 350 tables, dealing with such varied matters as rough-turning En 2 C.H.R. steel with differing cutting tools, effects of various heat treatments of steel, properties and machining constants for B.S. spring steels, cutting speeds for fine turning and boring, time to drill a hole 1in deep, multiplication factor for calculating the cutting force, chip thickness with pinion cutter as tooth is formed, cutter approach for slab mills, weight of Bakelite moulding powders, etc.

Iron and Steel Directory and Handbook, 1950

London: THE LOUIS CASSIER CO., LTD., Dorset House, Stamford Street, S.E.1. 1950. $5\frac{1}{2} \times 8\frac{1}{2}$. 302 pp. Price 25s.

Comprehensive directories, and handbooks, covering one specialized trade or industry are always invaluable to large numbers of buyers. This volume, relating to the iron and steel industry, was well known before the war and now makes its first appearance since 1939, this being the sixth edition. It has been brought up to date in every respect, the principal revision covering the analyses of pig irons and the various B.S.S. for ferrous materials. It lists the pig iron manufacturers, the blast furnaces, the ironfounders, the steel works (the two latter including directors' names, company capital, etc.), the iron and steel groups, and the iron and steel trades' associations and societies. The technical sections of the book cover such matters as recommended compositions of nickel cast irons, fuel oils, specific gravity of cast iron, cast iron and steel stock tables, physical constants of pure iron, M.S.D.T.D. specifications, etc. There is also a directory for buyers.

Besides being invaluable to buyers of iron and steel castings, pig iron and steel, etc., there is much information included that will be of value to metallurgists and engineers concerned with the manufacture or use of iron and steel in quantity. The directory for buyers is a comprehensive one, though every company engaged in manufacture under each heading is by no means included. In short, the book comprises a "Who's Who" of the iron and steel trade, together with all possible information concerning their products that can be included in table form, in addition to a considerable number of formulæ and rules relating to the manufacture of all types of iron and steels.

Practical Management and Works Relations

By A. C. Whitehead.
Manchester: EMMOTT & CO., LTD., 31, King Street West. 1949. 139 pp. $4\frac{3}{4} \times 7\frac{1}{4}$. Price 3s 6d.

Every industry is now making an all-out effort to increase the rate of production, and it is frequently thought that the principal way to do this is to "push" the workers to their utmost capacity. The ways and means of pushing, however, have different results and quite obviously, these results have a very definite bearing upon the relations between management and workers.

Mr. Whitehead is an expert on these matters and readers of this book will quickly appreciate that all those many factors which go to provide increased "comfort" for the worker, are very important indeed in securing the extra output. Not enough attention is given to the ideal heating of a factory, to its lighting in relation to the nature of work being done in each department, to the general orderliness and cleanliness. Possibly some thought is given to this when a new factory is being designed, but insufficient attention is devoted to it in older works, and it is really work for experts. A consultant should not cost his employers money, he should save it, and his advice in connection with matters affecting output should pay big dividends.

Some of the views expressed in this book are in line with American opinion, but few can doubt that the subject has been closely followed in the U.S.A. and we have something to learn from production methods over there. There are, at present, numerous books covering this same subject, but the amount of valuable information provided in this book is considerable, and it certainly stimulates the reader to further thought on this subject.

CAST CAMSHAFTS

The Development and Application of Monikrom High Duty Cast Iron

As high duty cast iron is now widely accepted as a most suitable material for internal combustion engine camshafts, it is of interest to learn something of the part played in its development by the largest producers in this country of this type of camshaft. The Midland Motor Cylinder Co. Ltd., Smethwick, Staffs, whose well known "Chromidium" cast products have been described in hese pages from time to time, appreciated some 15 years ago the technical and economical advantages to be obtained through the use of high duty cast iron camshafts. Therefore considerable research was undertaken to develop a composition that would give optimum service results at a lower cost than was possible with the more widely used stamped steel camshaft. Typical cast camshafts are shown in Figs. 1 and 2.

For economic reasons it was deemed advisable to develop a material that would eliminate the necessity for heat treatment and hardening processes, since experience had shown that such processes were the fundamental causes of high scrap figures in many of the camshaft production shops in the automobile industry. During the period of metallurgical development, the Company carried out day and night running tests on small single-cam rigs under varying conditions of load, speed and lubrication. Eventually a material, which included molybdenum, nickel and chromium as alloying elements, was chosen on its merits.

These alloying elements give the material the desired mechanical and physical characteristics. They also form the basis for the name "Monikrom" under which the material is registered. The development of a material with the requisite physical and mechanical properties was of fundamental importance. Equally important was the development of the casting method for "Monikrom" camshafts. Actually the method employed completely eliminates the need for subsequent hardening operations. This not only reduces costs but also obviates the danger that further troubles will occur in processing.

Very skilled foundry technique is necessary to ensure the production without distortion of shafts ranging from a few inches to 48in in length. The description "straight" is, of course, a relative term when applied to a cast camshaft, but every endeavour is made to maintain all normal automobile shafts within a maximum of $\frac{1}{32}$in out-of-straight. Every shaft is checked to ensure that the permissible out-of-straight tolerance is not in any way exceeded.

In preparation for the test the shaft is mounted in a special centring machine for centring each end. Centring is effected with a standard 60 deg "G" Slocomb drill that has an initial diameter of 0·187in and a maximum body diameter of 0·437in. The depth of drilling is such as to produce a diameter of $\frac{5}{16}$in–$\frac{3}{8}$in at the mouth of the 60 deg. cone. After being centred, the shaft is mounted in a special jig between ball-mounted centres and rotated by hand while a height gauge is applied to ensure there is a sufficient machining allowance on the cams for cleaning up in the grinding operations. This check on every shaft ensures that there will be little or no machine shop rejections due to out-of-straight shafts. The maintenance of straightness within the specified tolerance is very important since the cams are cast to form with only a relatively small allowance for rough and finish grinding. As the cam tips are of white iron, which is

Fig. 1. A range of Monikrom camshafts as cast.

Fig. 2. Monikrom camshafts after machining.

extremely hard, they are machinable only by grinding.

The chemical composition of "Monikrom" and its mechanical properties are :—

Total carbon	..	3·10–3·40 per cent.
Silicon	..	2·00–2·40 per cent.
Sulphur	..	0·100 per cent. max.
Phosphorous	..	0·200 per cent. max.
Manganese	..	0·50–0·080 per cent.
Nickel	..	0·15–0·25 per cent.
Chromium	..	0·80–1·00 per cent.
Molybdenum	..	0·15–0·25 per cent.
Tensile strength (B.S. 0·564 dia. test piece)	....	19 tons/sq.in.
Modulus of rupture (B.S. 0·875 dia. test piece)	....	36 tons/sq.in.
Brinell hardness of shaft		240–280

The nose of each cam is produced with a white iron structure that has the necessary load carrying capacity and wear resisting qualities without being directly related to the Brinell hardness number. This characteristic is completely different from that exhibited by a case hardened steel shaft, a point not always understood and appreciated by those dealing for the first time with cast camshafts. In the foundry it is quite easy for the trained inspector to satisfy himself by visual examination that the necessary structure has been obtained, and if any doubt arises it can be resolved by a simple file test.

However, where a user has been accustomed to accept or reject cams by indent hardness measurements, it is sometimes considered advisable for the design department to specify a hardness value for use by the inspection department. In such cases a minimum hardness of Rockwell C35 should be specified, since it is certain that the required metal structure will be present at and above this figure.

Service properties

As a camshaft material "Monikrom" has many technical advantages that have been fully proved in service in many different internal combustion engine applications. The graphitic structure of the iron with its close grained pearlitic matrix provides a surface that is particularly suitable for oil retention and load carrying. At the same time the natural graphite lubrication prevents the "scuffing" so often encountered with metallic materials when near-dry surface rubbing conditions are accidentally incurred.

This material also has advantageous internal damping characteristics. They are such that the vibrations are considerably damped and consequently there is a truer path of contact between the cam and the follower and the valve operating mechanism is generally quieter. Furthermore, "Monikrom" has better machining properties than have other materials commonly used for camshafts, and because of the manner in which the shafts are produced only a minimum amount of stock has to be removed. At the same time, the wear on a set of patterns even with large quantity production will be far less than on comparable dies for steel stampings, so that over long periods of production the machining allowances on "Monikrom" camshafts are much more consistent than those for steel stampings.

Another advantage is that the cost of a pattern is much less than that of a corresponding die. Furthermore, pattern alterations are much less costly than alterations to a set of stamping dies. This is particularly important in the case of experimental or prototype models where there is a possibility of subsequent modification to suit cam form or timing requirements for production quantities.

Because of the special casting technique that is employed "Monikrom" camshafts are produced with the cams in the hard condition when they leave the mould, so that they only require grinding to a smooth surface and correct form to be ready for use in the engine. There are, of course, other methods of producing cam hardness to withstand wear and it may be of interest briefly to describe the more commonly employed.

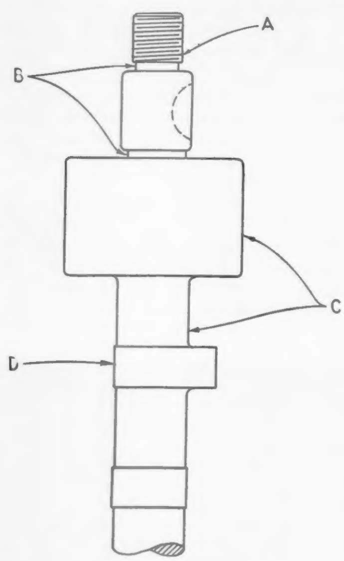


Fig. 3. Undesirable features in cast camshaft design.

(A) Small section threaded portion.
(B) Sharp undercuts.
(C) Sudden changes of section.
(D) Insufficient clearance between base circle diameter and shaft diameter.

For example, quench hardening may be employed. Where it is to be employed, the shafts are made in the normal manner in moulds with the whole casting in the "soft" condition. After it has been fettled, the shaft is placed in a special jig and the cam lobes are heated, either individually or all simultaneously, until the temperature is above the critical change point of the metal. The heat supply is then cut off and a quenching medium applied, which may be water, oil or even air. This produces a martensitic structure that is very resistant to abrasion and has a hardness figure of Rockwell C45–C65. This method of producing cam hardness has the disadvantage that cast iron is a difficult material to heat and quench without setting up severe surface stresses which may cause cracks to develop. It also entails expensive jigging arrangements with a capital outlay for a fuel supply system, to say nothing of the fuel costs.

Another method of producing cast camshafts is to use a metal composition which will be just on the verge of a mottled or white iron structure so that the comparatively thin noses of the cams will be automatically produced in the "hard" condition. This method can be applied only to certain sizes and shapes of cams. Even so, it is not an easy technique to employ. The great danger of this process lies in the possibility that parts other than the cams, such as bearings, gear blanks and driving flange, may be so hard as to be virtually unmachinable.

The special casting technique used in the production of "Monikrom" camshafts ensures that the cam lobes have great wear resistance while the remainder of the shaft has very good machinability. Furthermore, "Monikrom" in its unhardened condition has physical and mechanical properties particularly suited to the machining and application of oil pump driving gears which are so often incorporated as part of the camshaft in the form of spiral or "skew" gears. Furthermore, if a fuel pump eccentric is incorporated in the shaft design, it will be fully capable of the required duties without any subsequent hardening operation when made in "Monikrom."

No matter what method is used for the production of cast camshafts, many technical difficulties have to be overcome. The special method used by The Midland Motor Cylinder Co. Ltd. is the result of long research, but even so the strictest control must be exercised over day-to-day operations to maintain the specified high standard of quality. Actually, the technique is so closely controlled that a very large continuous production is maintained on many types and sizes ranging from two to sixteen cams on a shaft and from 2lb to 45lb in weight.

The low overall cost of the product and freedom from trouble in the machine shop may often be the reasons for choosing to use a high duty cast-iron camshaft. They are good reasons, but it must not be forgotten that the decision to use such shafts is often based solely upon technical advantages and not on economic considerations. These advantages include :—

(1) As compared with case hardened steel, cast iron will cause less wear on mating materials.

(2) The lower modulus of rigidity gives a better damping value, thus reducing vibration characteristics that tend to make the valve gear noisy.

(3) The danger of thin or weak case hardening is eliminated.

This last point is worthy of closer attention. It is recognized that if the

surface hardness of a material is obtained by some form of externally applied process, the resulting hard material is usually in the form of a skin of measurable depth with a very definite line of demarcation between hard and soft. This skin may have insufficient strength to carry the applied load and surface breakdown will occur with subsequent rapid wear.

With the process used in the production of "Monikrom" shafts the depth of hardened material is so great, and there is such a gradual merge from the hard structure to that of the softer pearlitic grey iron, that the applied load cannot cause surface breakdown. In fact, undue wear can occur only when there is abrasive or cutting action due to excessive loading in contact with a harder material that has been given an insufficiently fine surface finish.

A wide choice of tappet material is possible for use with "Monikrom" shafts. Experience has proved that the chilled iron tappets that are so commonly used in the automobile industry give very satisfactory mating with this type of shaft. The harder, case-hardened steel tappets are equally satisfactory. These require a very high polish finish if a considerable load has to be carried. This is necessary to ensure that any coarse grinding marks do not act as cutting edges on the relatively softer iron.

Fig. 4. Cam sleeves for large diameter camshafts.

Design features

When a complete change of material is made in an engineering component it is logical to assume that there may be need for design modifications, either in shape, in dimensions or in both. This is necessary to adjust the function of the component to suit the mechanical and physical properties of the material. Briefly, a design that may be completely satisfactory for a steel stamping may not be suitable for a cast camshaft.

Some of the more undesirable design features are shown in Fig. 3. For example, small screwed portions for fixing driving gears should be avoided, since there may be a risk that too long a spanner will be used with perhaps a final blow with a hammer to line up a split pin hole or to obtain the degree of tightness thought to be necessary. Such treatment may fracture the end of the shaft. This risk could, of course, be eliminated by the use of a torque spanner.

If a shaft is slender, it should be well supported in bearings, otherwise undue deflection may occur and cause noisy valve gear and excessive wear of the oil pump gear if this is incorporated as an integral part of the shaft. It is important that before machining there is adequate clearance between the base circle diameter of the cams and the body of the shaft. The tolerances should range from about 0·030in for the smaller shafts to about 0·060in for large and very long shafts.

There should not be any sudden changes from small diameters to large diameters since uneven sections give rise to casting difficulties. When necessary, shafts may be drilled right down the centre for lubrication purposes. If this is done, the design must be such that sufficient metal is left, particularly at the ends where drives by means of keyways may be incorporated.

The distance between adjacent cams, or between cams and adjacent bearings should be kept to a minimum of ¼in. With a smaller distance the thin portion of sand in the mould would cause trouble in the foundry. Sharp corners should be avoided as far as possible and fillets should be kept to a maximum as this results in cleaner castings. It will be appreciated that with a cast camshaft there is no machining down the sides of the bearings and cams, and it is possible to incorporate varying sized fillets with little or no difficulty.

When gears are incorporated for driving the oil pump and distributor, several points must be considered if subsequent service troubles are to be avoided. However, when these necessary requirements are met, the gears cut from a blank that is an integral part of the cast shaft give every satisfaction.

High duty cast iron is an excellent bearing material and has considerable load carrying capacity, but it is softer than case-hardened steel. Therefore, when a case-hardened steel mating gear is used, the rubbing surfaces of the gear teeth must be given a high polish finish after case hardening, otherwise any fraize or rough machining marks will act in effect like a milling cutter and will tend to cause excessive wear on the high duty cast iron.

It is well known that skew gears, the type normally used for driving automobile oil pumps, are in certain respects inefficient since the teeth actually work on point contact when new, and a definite area over which the load may be distributed is obtained only by deflection of the material. When the gears have been run-in they acquire quite a considerable area of contact. It is particularly during this running-in period that great care should be taken to preserve the surface of the "Monikrom" gear teeth. The load carrying capacity of a gear tooth is determined by the size of the tooth and experience has shown that any size smaller than 14 diametral pitch will lead to premature failure. For all normal internal combustion engine oil-pump drives 14 D.P. has been chosen as the minimum for high duty cast iron gears.

In order satisfactorily to obtain the necessary surface condition on the gear teeth in the minimum and with the least danger of excessive wear in service, it is recommended that the mating gear should be made either in another cast iron of similar quality to the high duty cast iron or chill cast phosphor-bronze.

To speed up the running-in period, it has been found good practice to give the camshaft some surface treatment such as phosphating. This treatment is usually of the low-temperature acid bath type that changes the surface of the material to a metallic phosphate. The phosphate layer is very thin, but it has a very good load carrying capacity and provides a structure for holding oil, thus carrying excessive loads over high spots during the running-in period.

High duty cast iron cams are now being widely used in large industrial and marine engines. For such applications the common practice was to make the cams as single pieces and bolt or peg them on to a steel shaft in position in the engine. This is a costly arrangement and a lengthy assembly job. A comparatively recent alternative development is shown in Fig. 4. This cam sleeve, as it is called, comprises three cams, that is a fuel cam, an air cam and an exhaust cam, cast integrally on one hollow shaft. These components may be used for a single cylinder engine or threaded along with another similar component on to a steel bar to suit a twin cylinder, or the building up may be extended to as many units as are required to suit the number of cylinders per engine.

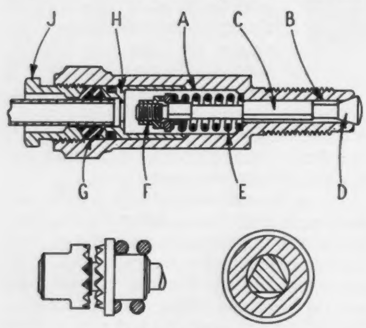
CURRENT PATENTS

A Comprehensive Review of Recent Automobile Specifications

Fuel injection nozzle

IT is claimed that this fuel nozzle for direct injection engines, although of simple construction, can be made extremely light and compact. The body, with an externally threaded reduced stem, has a chamber A communicating with a bore B defining the fuel flow passage. Valve C has a stem of triangular section with a relieved portion adjacent the tapered spray tip D. The long cone and seat of this arrangement, it is suggested, ensure the maximum washing effect as the fuel is discharged and tend to prevent accumulation of carbon or lead deposits.

Loading the valve is helical spring E bearing against a shouldered retainer slidable but not rotatable on the triangular stem and secured by an adjuster nut F. Contiguous faces of the retainer and nut are formed with complementary radial serrations which are engaged under the



No. 618918.

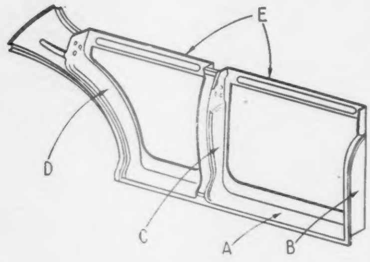
constraint of the spring to maintain the nut in its adjusted position. A special spanner with extended pilots depresses the retainer against the spring to unlock the serrations when it is fully engaged on the nut.

Welded to the end of the fuel line is a metal ferrule over which is moulded a rubber gasket G. This is seated on a bushing H, pressed into the nozzle body and sealed by a gasket, and is retained by a gland nut J. *Patent No.* 618918. *Bendix Aviation Corp. (U.S.A.)*

Body side panel assembly

PARTICULARLY applicable to the integral form of construction, this invention relates to side panel assemblies which are adaptable to open, cabriolet or landaulet body types as well as the more common saloon structures.

The facing panel is a one-piece pressing of light-gauge sheet metal extending from the floor to the waistline. At the base it is shaped to form front and rear door sills A and its front end has an upright section forming a facing pillar B for the front standing pillar. Between its extremities is a channel section upright C constituting facing pillars for the centre pillar. At the rear end is a dog-legged panel D merging into the base of the facing pillar for the rear standing pillar. The two door openings thus formed are not stamped out completely but part of the metal along the upper run is left intact



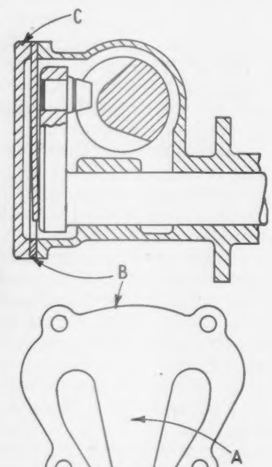
No. 620076.

to serve as struts E rigidly interconnecting the associated door facing pillars. These struts, which may be stiffened by a longitudinal groove swaged during the initial forming operation, ensure that the facing pillars maintain their relative positions before and during assembly.

When the panel has been incorporated in the body structure and all the surrounding panels have been firmly attached, the struts spanning the door openings are removed by shearing and the doors can then be hung. *Patent No. 620076. Morris Motors, Ltd., and R. Welton-Cook.*

Cam-and-roller steering gear

IN gears of this type it is usual to support the rocker arm directly or indirectly from the cover plate. Any slackness which may develop can be taken up by an adjusting device but it is not uncommon for an abnormal stress to impart a permanent set to the cover plate. In this proposal a spring tongue is provided to engage the end of the rocker arm and is sufficiently stiff to remain spaced from the cover plate under all normal working stresses. The tongue A may be part of a plate B secured between the housing and cover plate C. An initial set is given to the tongue so that its free end extends out of the plane of the plate and exerts

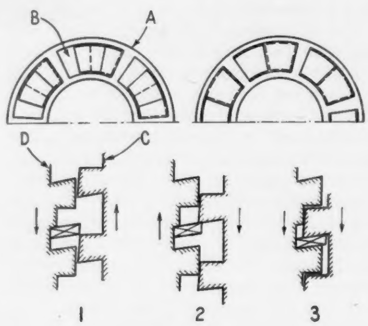


No. 620274.

a predetermined axial pressure on the rocker shaft when the parts are assembled. If desired an adjuster screw in the cover plate may be provided to permit variation of initial pressure exerted on the rocker arm. As the strength of the spring tongue is predetermined to a value such that it can only be deflected into contact with the cover plate when an abnormal stress is imposed, the tongue cannot be overstressed and will return to its original setting. A plurality of spring plates may be used in order to produce a laminated spring effect. *Patent No.* 620274. *R. Bishop and R. H. Johnston.*

Baulking ring

THIS method of effecting the desired partial rotation of a baulking ring interposed between axially movable and axially fixed dog clutch members of a variable speed gearing will not materially



No. 620099.

increase the overall length of the clutch assembly. The baulking ring A is provided with circumferential slots B substantially equal in length to the combined width of a dog of the movable member C and a dog of the axially fixed member D. Radial divisions between the slots are formed to project a short distance towards the axially-movable member and their face extremities are given an appropriate "lead" or inclination complementary to the lead on the face of the dogs of the movable member. When the clutch is disengaged, the dogs of member C override the projections on the baulking ring and by frictional engagement of the faces cause the ring to occupy an angular position, shown at 1, such that the dogs on member C lie against one end of the slots in the ring. Member C is urged by spring pressure towards member D but engagement is impossible so long as C is rotating faster than D.

As the speed of C begins to fall below that of D, as indicated in 2, its dogs engage behind the projection on the baulking ring and cause the latter to rotate backwardly in relation to member D. As soon as the relative angular movement of the baulking ring is sufficient to open fully the slots, the dogs of member C slide into engagement under the spring pressure, as at 3. *Patent No. 620099. David Brown & Sons (Huddersfield), Ltd., and A. Taylor.*

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